PROGRESS REPORT ON EXPERIMENTAL USE OF FIRE-BREAKS WITHIN NATIONAL FOREST TIMBER SALE AREAS IN THE CALIFORNIA REGION

BY

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE REGION FIVE MCMXXXV

Characteristic stand of ponderosa pine on the experimental area - Lassen National Forest.

FOREWORD

Certainly both civic duty and prudent business management demand that all engaged in lumbering should give serious consideration to the slash menace which results from this activity. On all cutting areas where this has not been done, adequate measures should be devised and put into effect to prevent the occurrence of slash fires and to aid in their control.

When the first National Forest cuttings were made during the early part of this century, the obligation to deal with this problem in an exemplary manner was recognized by the Forest Service. Later, many states put into effect legislation requiring slash hazard reduction. More recently, the Forest codes have dealt with it, also.

Foresters generally recognize that the brush piling and burning system, which for many years has been the standard requirement in California National Forest timber sales, is effective in disposing of the most inflammable portion of the slash. It is also recognized that this method is expensive and that the benefits derived are to a considerable degree, temporary.

One of the most effective substitute measures which promises to cost somewhat less than brush piling and burning and to bring with it lasting protective improvements such as firebreaks, lookouts, telephone lines, etc., is described in detail in this progress re-

port as actually instituted on two typical areas, each representative of very different, but prevalent, California timber types. This report carries these experiments through the stage of heavy initial investment. More or less maintenance and protection work is still necessary on both areas for an indefinite period, until a normal condition of hazard has been reached. The work yet to be done and the duration of the period of this work will be determined by the judgment of the Forest officers who are responsible for the protection of the areas concerned. When conditions are again normal, a final account of the undertaking will be prepared which will show more clearly the utility and the cost of the firebreak system as contrasted to the brush piling and burning system. It is hoped that the exposition of methods and the cost records in this report may be of assistance to timber land owners and lumbermen who are searching for a solution of the problem of slash hazard reduction.

To the officers and employees of the Fruit Growers Supply Company appreciation is due for the initiation of the experiment on land owned by that company, for well performed firebreak construction and other physical work connected with the experiment, for the complete records kept, and for energetic and effective fire suppression upon the experimental area. Mr. Walter B. Denton, the employee who had direct charge of the work on the company's land, is responsible in large measure for the success of the experiment. Much of the information in this report was compiled from records prepared anmually by Mr. Denton.

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June 7, 1935.

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INTRODUCTION

The economic disposal of the slash resulting from logging operations in California, has for a number of years been one of the important problems confronting the lumber industry. Munger and Westveld state that (2) "until recently slash on private lands has been treated wholly with a view to the cheapest effective abatement of the fire hazard without thought for the continued productivity of the land. This is unfortunate since most of the land now being logged is not only non-agricultural, but in fact well suited to continuous timber growing in conjunction with forest grazing. It is very desirable, therefore, that in the course of logging there be employed economically sound methods of slash disposal which will be advantageous for the continued productivity of the land and at the same time reduce the fire hazard."

Various methods of slash disposal, ranging from broadcast burning to piling and burning, have been employed on California cutover areas. Costs range from a few cents per acre to as much as 75 cents per M.B.M.

The purpose of this bulletin is not to discuss the need for or to describe the various methods of slash disposal, but rather to present in detail two hazard reduction experiments as conducted on the Stanislaus and Lassen National Forests.

Ever since the first sales of National Forest stumpage were made in the California pine region over thirty years ago, the piling and burning of slash has been a requirement in timber sale contracts. During the last nine years in particular, this work has been thoroughly standardized; it is recommended by its simplicity and effectiveness.

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(1) Rearranged by A. B. Everts, Associate Code Examiner.

(2) See P.3- Technical Bulletin No. 259, U.S.Department of Agriculture series "Slash Disposal in the Western Yellow Pine Forests of Oregon and Washington" by Thornton T. Munger and R. H. Westveld.

The ideal method of protecting the values on cutover lands against destruction or injury by fire should be one of low cost, lasting value and minimum damage. With these requisites in mind a system of firebreaks thruout slash areas, supplemented by intensive patrol, adequate detection and adequate communication facilities has much to recommend it, in theory at least.

Bunched logs and piled brush. Lassen National Forest timber sale cutover area.

Experienced, prudent administrators in any line of work demand the results of a test of any new scheme before using it as a substitute for an established practice which has given a substantial degree of satisfaction. Two excellent opportunities for making such a test of the firebreak system presented themselves on timber sale areas in the California Region in 1923 and 1926 on the Stanislaus and Lassen National Forests, respectively.

The Forest Service was willing to deviate from the established practice of piling and burning of slash in order to secure data

of general interest to industry in regard to the cost, the relative advantages and disadvantages of each system, the length of time it takes slash to disintegrate or return to a normal hazard basis and to work out a system for use on private lands which costs less than piling and burning.

OLD MINER'S DITCH HAZARD REDUCTION EXPERIMENT - HAZARD REDUCTION AGREEMENT

In October 1920 the Pickering Lumber Company, of Standard, California, purchased the National Forest stumpage, estimated to be about 147,000 M.B.M. on the Old Miner's Ditch Chance - Stanislaus National Forest. The timber sale contract contained the usual hazard reduction clauses which provide that unutilized tree tops shall be lopped and brush piled in compact piles in accordance with the requirements of the Forest Officer in charge, to be followed by burning during wet weather in the fall.

The Company's experience in connection with cutting about 27 million feet of stumpage under this contract in 1922 indicated that this brush disposal work would cost about 45 cents per M. After some negotiations the Forest Service agreed to relieve the Company of all further brush disposal, except the lopping of tops, provided the Company would deposit in a cooperative fund, as called for, a sum equivalent to 30 cents per M for each thousand feet of merchantable timber cut and scaled. With this fund the Forest Service agreed to deal with the slash hazard by the use of the firebreak and patrol system. Through this transaction the lumber company reduced its operating cost about 15 cents per M and the Forest Service secured an opportunity to experiment with a new system of hazard reduction on a typical donkey logging area on the western slope of the Sierra Nevada - a zone where a large amount of National Forest stumpage was being currently cut.

Area and Cut of Timber

The total area embraced in this experiment is about 3,800 acres of land cut over between 1922 and 1927 from which a cut of 132,365,790 feet B.M. was derived, or about 35 M per acre. Brush had been piled and burned on about 1,100 acres of this area before the experiment was instituted. On the remaining 2,700 acres, from which a cut of 105,365,700 feet B.M. was derived, or about 39 M per acre, the limbs were lopped from the unutilized tops and left lying on the ground, together with all other refuse which resulted from cutting. The large amount of timber removed from this area per acre is indicative of the excellent quality of the site. This cut was made up by species of 39% ponderosa pine, 34% sugar pine, 18% white and Douglas fir, and 9% incense cedar.

Forest Types

Three of the most prevalent and fire hazardous forest types in commercial timber stands on the west slope of the Sierra Nevada are well represented on the area, namely, the sugar pine-ponderosa pine type, the sugar pine-ponderosa pine-fir type and the sugar pine-fir type. A small acreage of ponderosa pine type also occurs on the exposed ridges. Incense cedar is found scattered through all types as usual in such stands. Type boundaries are not sharply delineated. Rather the various combinations of species tend to blend together. Usually the sugar-pine-fir type prevails on north and northwest exposures while the warmer south and southwest exposures bear mixed stands of sugar and ponderosa pine of varying composition.

Topography

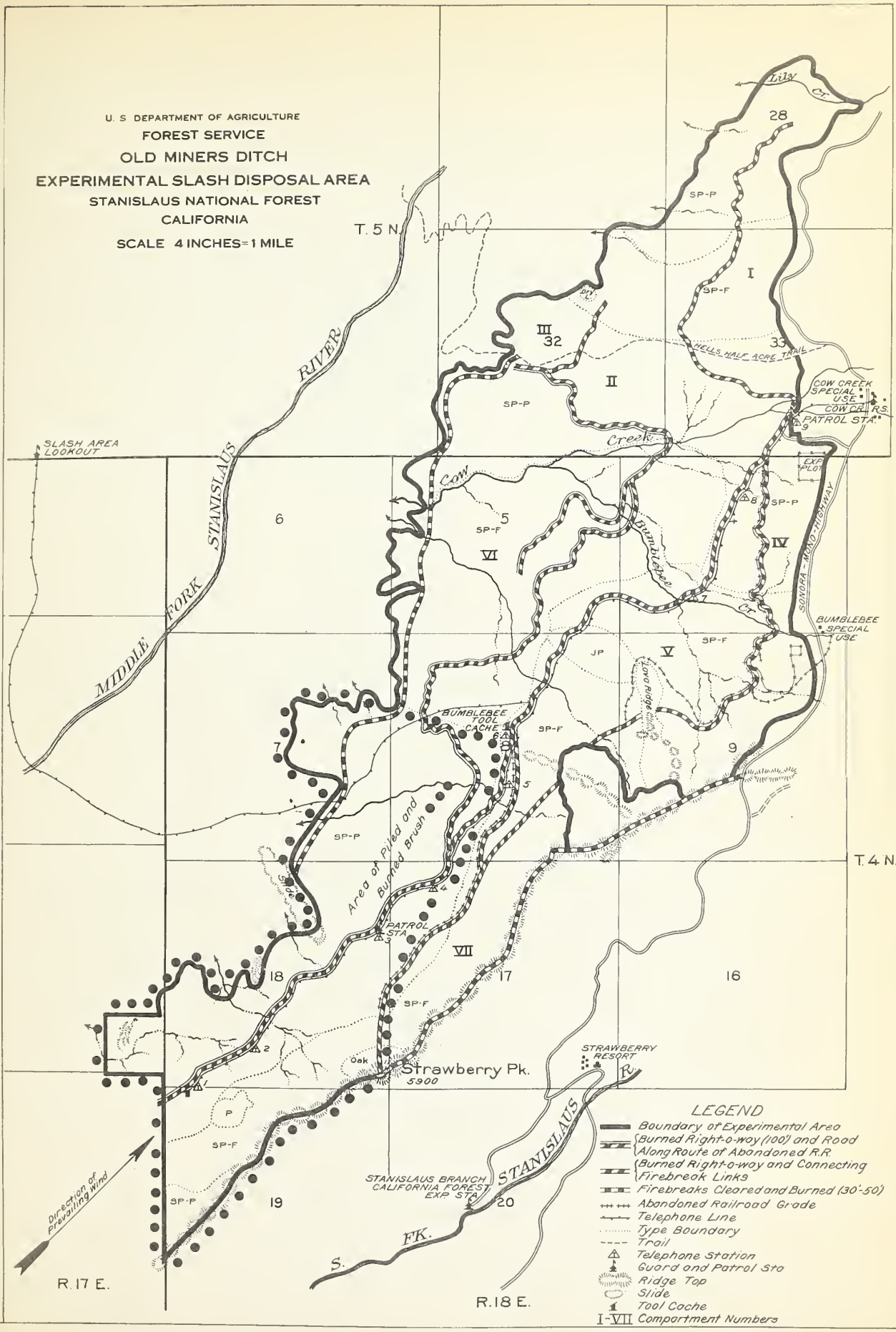
Topographically the area selected for experiment is situated on the upper westerly slope of Strawberry Ridge which constitutes a portion of the divide between the drainages of the Middle and South Forks of the Stanislaus River. The Sonora-Mono road, a trans-Sierra highway of secondary importance, traverses the eastern edge of the area for some distance (see map, page 5). The general westerly exposure of the tract is broken by level benches, small basins, and the steep canyons of several small tributaries of the Middle Fork of the Stanislaus River. The average slope is about 15%. Elevations on the area range from 4,250 feet at the western edge to 5,900 feet on top of Strawberry Peak.

Reproduction and Undergrowth

The amount of reproduction upon the area is about average for National Forest cutover areas of the same age on the west slope of the Sierra Nevada within similar forest types which have been logged by donkey engines. In connection with an estimate of the reserve stand which was made during the field seasons of 1929 and 1930, following cutting, detailed reproduction counts were secured on 1% of the area. Table No.I shows a summary of these data for trees under 4" D.B.H. on a percentage basis by species and two size classes.

TABLE 1

SPECIES	Percent of Stocking by Size Classes		
	0-6'	6' to 3.5"	Total
Ponderosa pine	1.2	.4	1.6
Sugar pine	1.3	.3	1.6
White fir	4.8	2.9	7.7
Incense cedar	8.9	2.2	11.1
TOTAL	16.2	5.8	22.0


U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
OLD MINERS DITCH
EXPERIMENTAL SLASH DISPOSAL AREA
STANISLAUS NATIONAL FOREST
CALIFORNIA
SCALE 4 INCHES = 1 MILE
T. 5 N.
T. 4 N.
R. 17 E.
R. 18 E.
MIDDLE FORK STANISLAUS RIVER
Lily Cr.
Cow Creek
Bumblebee Cr.
SONORA - MINO HIGHWAY
WELLS HALF ACRE TRAIL
COW CREEK SPECIAL USE
COW CR. R.S. PATROL STA.
BUMBLEBEE SPECIAL USE
EXP. PLOT
SLASH AREA LOOKOUT
BUMBLEBEE TOOL CACHE
Area of Piled and Burned Brush
PATROL STA.
Strawberry Pk. 5900
STRAWBERRY RESORT
STANISLAUS BRANCH CALIFORNIA FOREST EXP. STA.
S. FK. STANISLAUS R.
Direction of Prevailing Wind
SP-P
SP-F
JP
Dry
Oak
P
I
II
III
IV
V
VI
VII
LEGEND
Boundary of Experimental Area
Burned Right-o-way (100') and Road Along Route of Abandoned R.R.
Burned Right-o-way and Connecting Firebreak Links
Firebreaks Cleared and Burned (30'-50')
Abandoned Railroad Grade
Telephone Line
Type Boundary
Trail
Telephone Station
Guard and Patrol Sta
Ridge Top
Slide
Tool Cache
I-VII Compartment Numbers

Twenty-two percent of the area is stocked with young seedlings and saplings. 50% of this stand is incense cedar, 35% white fir (which includes a negligible amount of Douglas fir), 7½% ponderosa pine and 7½% sugar pine. There are no indications that the leaving of slash has had any appreciable effect upon the establishment of reproduction or its later development; however, this point was not given special study.

The undergrowth on the area, which is of importance in this connection because of its contribution to fire hazard, is composed largely of sweet birch (Ceanothus integerrimus), white thorn (Ceanothus cordulatus), bear clover (Chamaebatia foliolosa), manzanita (Arctostophylos patula), and bitter cherry (Prunus emarginata). On some of the higher and more exposed portions of the area where the original timber stand was thinned by fire before logging, this undergrowth is moderately dense, although even in these locations seedlings, usually white fir, are gaining a foothold in the old logging trails, in small natural openings, and to some extent even under the dense brush. An appreciable increase in the density of the ground cover of undergrowth has occurred since the logging of the area was completed in 1927. This is particularly true of sweet birch and white thorn.

Soil

The loose, sandy soil, which is of granitic origin, varies in depth from two to four feet and is underlaid by solid granite bed rock which appears in the form of occasional outcroppings.

Climate

Temperatures of about 10°to 15° Fahr. occur for short periods in December and January. July and August are the hottest months of the year with maximum temperatures of about 95°. Periods of low humidity and high fire danger are common during this period. Frosts may occur during nine months of the year, although killing frosts are uncommon between May 15 and September 15. No complete precipitation records for this locality are available. By interpolation and inference it is estimated that the average total annual precipitation on the plot is somewhat above 40 inches, including approximately 12 feet of snow. A large part of this precipitation (about 70%) is received between November 1 and March 1. During recent past years, prior to the winter of 1931-32, but little rain has fallen until late November and the depth of snow has seldom exceeded four feet at any time.

The Fire Danger

All the factors that make up a dangerous fire situation are present on this area. The large volume of timber cut per acre produced a corresponding volume of hazardous material in the form of limbs, needles and litter. Donkey engines and locomotives were used in logging, also a heavily traveled highway is adjacent on the east and a popular fishing stream, the Middle Fork of the Stanislaus River, on the west. These elements of the situation increase the risk of fire starting. Diversified topography and exposure to the prevailing southwest winds of summer add to the likelihood that a fire once started will be difficult to suppress before considerable damage has been done. It is readily apparent, therefore, that any system of fire protection applied to this area would be severely tested.

Test Period

In attacking the problem of protection it was at once self-evident that to secure results comparable to those secured by the standard system of slash piling and burning it would be necessary to continue the project until such time as a degree of hazard reduction was secured by slash disintegration and decay equivalent to the reduction secured through burning. This necessitated an assumption based largely on general experience and observation. It was finally decided to assume that such a condition would be brought about by 1935, or eight years after the completion of logging on the area, and 13 years after the start of the experiment. This allotted time will not be at an end until the close of the 1935 fire season. However, by estimating the patrol and lookout costs for the last year of the experiment, it is possible to arrive at a presumably accurate cost figure for the thirteen year period. No fires occurred on the area during six years of the experiment. Assuming that no fires occur in 1935, the last year of the experiment, we can also complete the fire picture, in theory at least.

White fir slash one year after logging. Note almost complete defoliation.

Protective Measures

After having fixed the duration of the experiment it was necessary next to select, in detail, the specific fire protection measures necessary to offset the hazard of the unburned slash and to estimate the cost of these measures. In considering the cost element it was very evident that unless the area could be safeguarded against fire danger at a somewhat less cost than by the use of the brush piling and burning system, there would be no worthwhile advantage in the change of method.

On the basis of these considerations a protection plan for the area was prepared which provided for a special fire lookout, primary and secondary firebreaks throughout, a special telephone system, also a patrol to aid in fire detection and to make the initial attack upon any fires which might occur. Adequate fire tools must also be at hand. A cost estimate indicated that the experiment could be conducted for 30 cents per M B.M. in round figures on the basis of the anticipated cut from the remaining uncut portion of the experimental area (2,700 acres). This cut amounted to 105,365,790 board feet, which, at the rate of 30 cents per M made

available a total cooperative fund of $31,609.74 for handling the protection of the area during the thirteen year period from 1923 to 1935 inclusive.

The 1,100 acres in the southwestern portion of the sale area was cut over and the resultant slash had been piled and burned before the firebreak plan was conceived. Because any fire which started upon this area would be very apt to spread uphill into the slash area it was considered a part of the experimental area. The detection and patrol services covered this area and one main firebreak along the railroad was constructed through it, from north to south, as shown on the map. Since the experimental expenditures on this area have been made for the protection of the 2,700 acre slash area they have been charged to the experiment. In deriving per acre and per M costs, therefore, the area of piled and burned brush has not been taken into account, although actually given the same degree of special protection on the slash area.

EXECUTION OF THE PROTECTIVE PLAN

Firebreaks

The original plan for firebreaks contemplated the construction of both a primary and a secondary system. The work on the primary breaks was handled in accordance with the following specifications:

(a) Pile and burn all inflammable debris on a strip 100 feet wide above all railroad grades.

(b) Dig trenches about 4 feet wide to mineral soil on the upper edge of all breaks.

(c) Burn strips about 100 feet wide below all railroad bridges.

(d) Clear inflammable refuse from a strip 50 to 100 feet wide along the lower boundary of the sale area to aid in fighting fires originating outside the area along the canyon of the Middle Fork of the Stanislaus River - a zone of high fire risk, especially in Beardsley Flat where a large railroad construction camp was located.

(e) After the steel has been removed from the railroad right-of-way convert this right-of-way into a motorway by removal of ties and grading.

The construction of the primary firebreaks was carried on progressively during a six year period following logging railroad construction and the logging of the area. A detailed history of the con-

struction of these breaks will be found on Page 56 of the Appendix.

The Pickering Lumber Company removed the rails from the logging railroad grades thruout the area in 1927. In 1928 the Forest Service commenced removing ties from these grades and preparing them for motor travel with tractor and grader equipment. In all, about 12 miles of this type of road was prepared, which has made all parts of the area more readily available since then to patrolmen and firefighters.

It is evident from the description of the topography of the area that the primary firebreaks are roughly parallel to contours. The location of the logging railroad grades and the usual rapid uphill spread of fire determined this arrangement.

Secondary firebreaks, running at right angles to the primary breaks, and thus dividing the area into blocks about ten acres in area, were originally contemplated. In the logging of the area with donkey engines the logs were dragged up the slopes, thus creating a fan-shaped system of irregular narrow trails to mineral soil, of varied width and spacing, which converged at the spar tree. It was thought that these trails could be cleared of inflammable material at moderate cost and that they would have a value in fire suppression emergencies which would be commensurate with their cost. Actual experience in their preparation soon indicated that the amount of clearing necessary had been under-estimated and that, due in part to this factor and in part to the inefficiency of labor then prevalent, the cost of preparing these secondary firebreaks would be out of proportion to their value. This conclusion was supported by the knowledge that these secondary lines after clearing, would not stop a fire, but would only serve as emergency backfiring bases. As such they were thought to have considerable value without further clearing, particularly since any fires which might occur would spread laterally at a comparatively moderate pace. In the judgment of the experienced firefighters who were planning the protection of the area more intensive patrol of the area would pay larger dividends in the saving of values from fire than the construction of these additional breaks, and, therefore, they were not built.

A secondary fire trail on the Old Miner's Ditch Area, Stanislaus National Forest.

Firebreak Costs

The area of unpiled brush protected by firebreaks amounts to approximately 2,700 acres, from which a cut of 105,365,790 board feet was derived. The total cost of firebreak and protection road construction, as shown in Table 2, amounted to $7,594.00. It is estimated that these firebreaks and protection roads will contribute to the protection of the area for a total period of about 25 years or up to the close of 1947.

Thus we derive a cost of $0.072 per M B.M. cut, or $2.81 per acre. The cut per acre on this area was about 38.6 M. Since the volume of timber cut per acre varies considerably within any given region, per acre costs are more dependable and useful than per M costs in preparing fire protection plans.

TABLE 2.

TOTAL AND PERIODIC COST IN DOLLARS

OLD MINERS DITCH SLASH DISPOSAL EXPERIMENT

1923 - 1935, inclusive.#

YEAR	Patrol Salariss	Horse Feed	Look-out Salary	TOTAL	TELEPHONE LINE: Construction, equipment and maintenance	TELEPHONE LINE: Depreciation	HOUSING: Construction and maintenance	HOUSING: Depreciation	TOOLS: Investment	TOOLS: Depreciation	FIRE PUMP: Investment and maintenance	FIRE PUMP: Depreciation	FIRE BREAKS & ROADS: Investment including burning	FIRE BREAKS & ROADS: #Depreciation (bassd upon use thru 1947)	MISCELLANEOUS: Invsstmente	MISCELLANEOUS: Depreciation	TOTAL INVESTMENT	TOTAL DEPRECIATION	TOTAL EXPENDITURES FOR PERIOD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1923	330	85	387	802	806	86	595	81	273	61	681	56	1,987	293	150	75	4,492	652	5,294
1924	1,100	--	550	1,650	10	86	131	81	90	61	6	56	2,310	292	27	75	2,574	651	4,224
1925	785	54	400	1,239	38	86	38	81	5	61	1	56	504	292	6	74	592	650	1,831
1926	972	26	532	1,530	100	86	47	81	2	61	35	56	220	292	171	74	575	650	2,105
1927	1,137	98	552	1,787	56	86	--	81	375	61	--	56	2,120	292	391	74	2,942	650	4,729
1928	1,146	111	600	1,857	100	85	191	81	18	61	--	56	453	292	45	74	807	649	2,664
1929	1,183	120	661	1,964	--	85	--	81	--	61	--	56	--	292	20	74	20	649	1,984
1930	594	38	432	1,064	--	85	--	81	30	61	--	56	--	292	20	74	50	649	1,114
1931	573	--	483	1,056	--	85	24	81	--	61	--	56	--	292	20	74	44	649	1,100
1932	484	14	429	927	--	85	24	81	--	61	--	56	--	292	8	74	32	649	959
1933	535	--	407	942	--	85	--	80	--	61	4	56	--	292	6	74	10	648	952
1934	489	12	489	990	--	85	--	80	--	61	--	56	--	292	--	74	--	648	990
## 1935	500	--	500	1,000	--	85	--	80	--	61	--	55	--	292	100	74	100	647	1,100
TOTALS	9,828	558	6,422	16,808	1,110	1,110	1,050	1,050	793	793	727	727	7,594	3,797	964	964	12,238	8,441	29,046
Cost per M+	0.0933	0.0050	0.0609	0.1591	0.0105	0.0105	0.0099	0.0099	0.0075	0.0075	0.0069	0.0069	0.0721	0.0360	0.0091	0.0091	0.1160	0.0800	0.2396#
Cost per Acre++	3.6400	0.2067	2.3786	6.2252	0.4111	0.4111	0.3889	0.3889	0.2937	0.2937	0.2693	0.2693	2.8126	1.4063	0.3570	0.3570	4.5326	3.1262	9.3514#

Footnots: All investmsnts, except firsbreaks and roads, deprsciated on the basis of a thirteen ysar period of usefulness. Firebreaks and roads will, undoubtedly, be ussful until 1947.

#Figurss bassd upon supposition Firebreaks and Roade still have a value of $3,797, or one-half deprsciatsd. Had complete deprsciation bsen figured costs would have been $0.2756 psr M and $10.7577 per acre.

1935 costs sstimated.

+Based upon 105,366 M
++ " " 2,700 Acrse

Total expenditures for period 1923-1935 ..... $29,046
Total available fund $31,610
Unexpended balance ae of January 1, 1936 ..... $ 2,564

Total cost per M = $ 0.2756
Total cost per Acre = $10.7577

The linear mileage of firebreaks and fire trails is 21½ miles of an average width of 77 feet, not including the 12 miles of motorway. The total acreage included in these firebreaks and trails is 200.4 acres. Their cost per mile is $331.26, per acre within breaks - $35.00.

The cost of the 12 miles of motorways which were built upon the railroad grades after the removal of the steel is included within the $7,594.00 total firebreak cost item. The cost of this motorway mileage amounts to $471.91, including $18.50 spent for tools, or a linear mile cost of $39.33. This figure is considered fairly representative of the cost of the efficient converting of broad gauge railroad grades into motorways under soil conditions similar to those which prevail on this area. It may be useful as a guide to land owners who contemplate using the system of protection herein described. A four-man crew was used in the construction of these motorways. The useless ties were left in place when steel was removed. They were taken up by hand labor. Then the grade was traversed twice with a "30" caterpillar tractor and an 8-foot blade road grader. The motorway was then in usable shape. The following season rocks and small slides were removed. These motorways have rendered all portions of the area readily accessible. For this reason and also because they furnish an excellent base for backfiring operations, they are regarded as an extremely important feature of any fire protection plan, and particularly so when the hazard is high on the area due to non-disposal of slash, or other cause.

Table No. 3 shows the approximate dimensions of these firebreaks, fire-roads and fire-trails.

TABLE No. 3

	Length	Width	Area
Firebreaks along railroad grades	14¼ miles	100 feet	172.7 acres
Protection roads (motorways)	12 "	20 "	29.0 "
Special fire trails	2¼ "	30 "	8.1 "
Special fire trails	3 "	50 "	18.2 "
Special fire trails	2 "	6 "	1.4 "
TOTAL	33½ miles	-	229.4 "

Fire compartments

The firebreaks divide the area into seven irregular compartments, as indicated on the map, some of which are not entirely enclosed. These compartments contain the following approximate acreages (see map):

Compartment No.	1.....	200 acres
"	2.....	900 "
"	3.....	90 "
"	4.....	280 "
"	5.....	440 "
"	6.....	590 "
"	7.....	200 "
TOTAL		2,700 "

The average compartment acreage is about 385 acres.

FIRE DETECTION AND COMMUNICATION SYSTEM

Detection

Any system of firebreaks which is constructed within reasonable limits of expenditure and which is limited to a reasonable percentage of the acreage protected, cannot be expected to stop a running fire under the climatic conditions which prevail in California forests during the summer months. Firebreaks such as those which have been described are invaluable, however, as bases for making effective attack upon such fires as resist the initial effort to suppress them by direct attack. "Get them while they are small" is the watchword of all effective fire fighters. Immediate detection of fires, their accurate location, quick communication of this information to those charged with initiating action, as well as speedy travel to a fire, are universally recognized as primary essentials of success in fire suppression work.

Within this experimental area detection service was secured by stationing a lookout on a prominent point on the easterly slope of the ridge west of the Middle Fork of the Stanislaus River, not over 1½ miles distant in an air line from the western side of the tract. From this location every portion of the experimental area was clearly visible, as well as a considerable territory outside its boundaries. In 1927 an 8x8 lookout cabin was constructed and since that time detection service has been available for 24 hours a day during the fire season, a period usually of about 150 days duration. Standard Forest Service lookout[1] equipment was employed in this phase of the fire detection work.

1- Those interested in lookout equipment will find a description on pages 55-60 of Department of Agriculture Bulletin dated May 29, 1914, entitled "Systematic Fire Protection in the California Forests."

Reports on the 31 fires which occurred between 1923 and 1935* show the efficiency of the lookout service. In eight cases the lookout made the first, and in six cases the second, report of fire. On the face of it this record is not impressive. However, it should be remembered that 68% of all the fires were caused by logging equipment or loggers. In many of these cases the fires were detected immediately by the men on the ground and suppressed by them. In such cases it appears quite likely that the patrolman who prepared the fire report neglected to mention detection by the lookout. If we leave out of consideration the 1929 Cow Creek fire, lookout's discovery time is 9 minutes and 50 seconds and his report time 1.61 minutes for the fires shown as reported by him. This record is in line with the best of modern performance.

During the life of the experiment, detection service has cost a total of $6,422.00. This amounts to $2.38 per acre for the period ($0.183 per acre year), or $0.06 per M feet B.M. cut. This cost of detection service is excessively high, due to the small size of the project (2,700 acres). Under average mountain conditions a primary lookout should serve at least 20,000 acres satisfactorily. On this basis the cost for the 13 year period would have amounted to about 32 cents per acre, or less than 2½ cents per acre year. Certainly this lookout rendered incidental service over an area larger than 2,700 acres. The records are incomplete as to outside area served or service rendered there.

Patrol

The excellent detection service furnished by the strategically located lookout is materially strengthened by intensive patrol of the area during the dangerous fire season each year which usually extends from about June 1 to some time in late October or early November. This patrol has four principal functions: (1) to detect fires along the patrol routes; (2) to suppress small fires which can be handled without assistance; (3) to secure assistance for handling larger fires and to aid in their suppression; (4) to police the area and enforce the special Forest Service regulations which govern its use, later referred to in more detail (see Page 19.).

While logging was in progress on the area, from 1923 to 1927 inclusive, the risk of fire starting was higher than later, due to the use of donkey engines and locomoties, as well as to the presence of the logging personnel. Table No. 4 indicates that 72.4% of all fires that occurred during the period of logging and 67.7% of all

* Assuming there are no fires in 1935.

TABLE NO. 4

CAUSES OF FIRES

Season	*LOGGING EQUIPMENT AND PERSONNEL									OTHER						
	Donkeys	Loaders	Locomotives	Back lines	Burning Settings	Blasting on Railroad	Brush Burning	Smokers	TOTAL	Lightning	Hunters	Campers	Stockmen	Blasting (State Highway)	Unknown	TOTAL
1923		2					1	1	4		1	1			1	3
1924	2	1	4	1	1	3	1	1	14				1		2	3
1925										1						1
1926		1	2						3	1						1
1927														1		1
1928																
1929										1						1
1930																
1931																
1932																
1933																
1934																
1935																
Total	2	4	6	1	1	3	2	2	21	3	1	1	1	1	3	10

*Logging of the area was very largely completed in the fall of 1926. No logging fires occurred thereafter. From 1923-1926 logging was responsible for 72.4% of all fires. For the full period 1923-35 inclusive, logging was responsible for 67.7% of all fires.

fires were caused by logging equipment and personnel. Of 21 such fires, the largest number (6) were caused by the oil burning locomotives. Wood burning donkey engines, engaged in log yarding, caused four fires and blasting in connection with railroad construction, and lightning, caused three each. It is of interest to note that only two fires were caused by donkey engines, other than loaders, and only two by smoking. These occurred prior to 1925. In that year special fire precautions, particularly directed toward preventing donkey engine and smoker fires, were made effective on all National Forest timber sale areas due to a serious outbreak of such fires in 1924.

The large amount of highly inflammable logging slash during the period prior to 1927 also created a comparatively serious fire situation. From the viewpoint of fire suppression, however, the condition during the period of logging was less difficult than subsequent to 1927 because of ready access to the equipment and man power of the timber operator.

From 1923 to 1929 two patrolmen were employed during the entire fire season each year and a third emergency patrolman was occasionally used for short periods of high danger. Two inexpensive patrol headquarter cabins were constructed on the area at strategic points, one on Cow Creek in the southern part of Section 33 for patrolman No. 1, who served the northern part of the area, and one in the eastern part of Section 18 for patrolman No. 2, who served the southern portion of the area (see map). The northern headquarters is known as Camp Cow Creek Patrol Station and the southern as Camp Bumblebee Patrol Station.

From these headquarters each patrolman covered systematically, on horseback, the portion of the area assigned to him for a four hour period each day. The railroad right-of-way was patrolled after each train. The remaining four hours of the day were spent within telephone call of the patrol stations. Patrol periods were "staggered" so that one patrolman was always at the telephone during the day. Horses remained saddled from 8:00 A.M. to 5:00 P.M. Each patrolman reported to the lookout at half-hour intervals either from his cabin, or from portable telephone connections along his patrol route.

When in the field each patrol was equipped with a McLeod tool (combination rake and hoe with detachable handle), axe, canteen, portable telephone and canvas carrying case for maps and papers. A two-inch scale map was carried which was divided into sectors by lines radiating from thelookout point at 10 degree intervals. Since these maps were identical with the one used by the lookout, they greatly facilitated the quick determination and description of the location of any fires reported to the patrolmen by the lookout.

The fire equipment at each patrol station consisted of a

loaded a 5-gallon back pack water can with hand pump, a Pyrene fire extinguisher, a 7-man cooking outfit, and one Evinrude 2-cylinder water pumper with 1,200 feet of fire hose.

The patrol has been able to reach 57% of the area within 15 minutes and the remaining 43% within 30 minutes. On large national forest areas of comparable value not over 5 to 10% is gener ally reachable within 30 minutes and not over 15 to 20% additional within one hour. This furnishes rather a striking index of the intensity of protection given this area which is again reflected in the record of acreage burned, discussed later.

Since the spring of 1930, only one patrolman has been employed on the area. This reduction in force was possible, in part, because of a measurable decrease in hazard due to disintegration of slash, but, primarily, on account of a lesser degree of risk which was a sequence of the cessation of logging operations and the increased access'bility brought about by the construction of the motorways.

The annual and total cost of the patrol is shown in the cost table on page 12. The total cost for the period (patrol salaries plus horse feed) amounts to $10,386.00, equivalent to $3.85 per acre for the period (29.5¢ per acre year), or $0.098 per M.

Communication

Prompt communication of fire detection information is equal in importance to prompt and accurate location of fires in the chain of action leading up to fire suppression. Thruout an extended period of fire experience and experimentation the Forest Service has tried every promising means of communication, including special messengers, the heliograph, sound signals, radio, and telephone. Of these systems, while the radio gives considerable promise of future usefulness, telephone communication is at present the most dependable and satisfactory, particularly for use in connection with permanently located detection stations. Eleven miles of special telephone line were constructed to furnish a communication network thruout this area. A tie to the existing telephone system was made at Cow Creek Guard Station on the main Sonora-Mono Highway. From this initial point a tree telephone line was constructed to the lookout via Cow Creek patrol cabin and Bumblebee tool cache. Then branch lines were installed from this main artery to the south line of the area through the Bumblebee patrol cabin along the line of the southern patrol route and from the Cow Creek patrol cabin north to Lily Creek along the line of the northern patrol route (see map, P. 5.). These branch lines were "dead ended" and were constructed and maintained to make it possible for the patrolmen to communicate with the lookout and the Cow Creek guard by portable phone while riding their routes. This system which was constructed at a cost of about $100 per

mile, has proven entirely adequate in every emergency and the expenditure of $1,110.00 in its construction has been thoroughly justified by the results secured. The depreciation on this telephone line amounts to $0.010 per M, or $0.411 per acre.

Fire Fighting Tool Caches

Three tool caches located at convenient points have been placed on the area. These contain fire fighting equipment for a total of 70 men, One large central supply is maintained in an old building left by the lumber company. This contains tools and cooking utensils for 50 men, also an Evinrude pump, 1,600 feet of 1½ inch hose and a side hill plow for constructing fire trench. The other two tool caches are housed in small metal kiosks at convenient points along the patrol routes. They each contain equipment for ten men. The two patrol cabins also are equipped each with a tool supply for four men. No fire of sufficient size has occurred on the area to require the use of the full complement of equipment.

Water is available in the several streams which traverse the area and the Evinrude pump and hose have been used to excellent advantage in a number of instances. No quota of fire suppression equipment designed to serve an area where water is available should be regarded as complete without a similar pumping unit of the best type.

The depreciation on fire fighting tools and fire pump to the end of 1935 amounts to $0.563 per acre or $0.014 per M. (See cost table, P. 12).

Regulation of Public Use

Measures designed to reduce the risk of the starting of fires must be given at least as much consideration in preparing a protection plan as those directed toward the detection and suppression of fires which occur. The Middle Fork of the Stanislaus River, just outside the lower boundary of this area, offers considerable attraction to fishermen, who have been accustomed to go back and forth at will between the river and the Sonora-Mono road. In an effort to prevent man-cause fires the area is closed to all public use during each fire season, except that permits are granted to those who wish to traverse it for business reasons. Gates, which are locked, have been placed at the entrances to the areas and fire prevention signs and notices of closure are prominently posted along the adjacent highway. A few trespassers, usually fishermen or hunters, have been discovered by the patrolmen. In general the closure notices have been observed and obeyed by the public.

FIRE TIME ELEMENTS, ACREAGE BURNED AND COSTS

TABLE NO. 5

YEAR	No. of Fires	AVERAGE TIME RECORD (Minutes)			AREA BURNED (Acres)					COST	
		Get-away	Travel	Control	Minimum	Maximum	Average	Total	Damage	Temporary Labor and Other Costs	Forest Officer and Other Contributed Wages
1923	7	3.6	7.6	34.2	.003	.500	.103	.720	$ 0.30	-	$ 79.31
1924	17	1.7	11.5	28.8	.001	7.000	.909	15.453	$67.75	$13.30	$704.23
1925	1	15.0	20.0	85.0	.750	.750	.750	.750	-	-	$ 36.02
1926	3	.2	.3	15.7	2 sq.ft	1.000	.333	1.000	-	-	$100.50
Pre-Season	*1	-	50.0	40.0	2.500	2.500	2.500	2.500	-	-	$ 8.80
1927	1	-	-	-	.017	.017	.017	.017	-	-	$ 7.35
1928	-	-	-	-	-	-	-	-	-	-	-
1929	1	0.0	15.0	45.0	.160	.160	.160	.160	-	-	$ 8.70
1930	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-
Total or Av.	31	2.4	9.5	30.2	2 sq.ft.	7.000	.705	20.600	$68.05	$13.30	$944.91

*Pre-season fire not included in average time record.
Average percent of area burned yearly --- .058 of 1%.

Only three fires have been attributed to public use (See Table No. 4, P. 16). There have been no flagrant cases of disregard of the exclosure regulations which have justified legal action and no serious criticisms of the closure.

RESULTS OF PROTECTION

The system of fire preparedness applied on this experimental area has been described in considerable detail. Undoubtedly the reader has become inquisitive by this time regarding the results obtained through the application of these rather elaborate precautions, for results are the real test of value in fire protection as in any other line of activity. Judged from this standpoint the results in this instance are striking, and on the whole, gratifying to those who have had to do with this project. Fire is a fickle jade, however, and it cannot be argued with any degree of assurance from past results that a damaging conflagration will not occur upon the area during some future fire season, although the precautions taken and the slow but sure deterioration of the inflammable material are decreasing the possibility of such a happening year by year. Table No. 5 shows the fire history of this tract in detail.

In 1926 one fire took place before the patrolmen and lookout were on duty. This has been disregarded in the time record averages because it has no bearing upon determining the efficiency of the special protective force assigned to the project. Average get-away time of 2.4 minutes, average travel time of 9.5 minutes, and average control time of 30.2 minutes indicate very satisfactory action on the part of the patrol and suppression forces. The short, average suppression time evidences the absence of large fires. None exceeded 7 acres and only three reached one acre in size. The average fire is .7 of an acre. The record of fires on timber sale areas on ten National Forests in this Region where brush piling and burning is required, for the years 1926 to 1930 inclusive, shows that a total of 72 fires occurred which burned over an area of 215 acres, or an average of 3 acres per fire. While both of these averages show low acreage burned the experimental area average for the same period is only 23% of the ten Forests' average. This showing indicates the possibility of securing a very satisfactory area burned record on a high hazard area by an intensive system of detection and suppression.

Of the total fire damage, amounting to only $68.05, practically all took place in the bad fire year of 1924 which is credited with 17 of the total of 31 fires. Total suppression cost for the period amounts to $958.21, which is 2.7 cents per acre year. The average cost per fire is $30.81.

In this National Forest Region at present it is considered

that an average yearly percent of burned acreage less than .2 of 1% indicates satisfactory performance by the fire forces. The years 1924, 1926 and 1928 were the most dangerous fire years in local fire protection history. The average annual area burned over in these three years (324,000 acres) is approximately 1.6% of the national forest acreage in the region. Contrast this with .058 of 1%, which is the average yearly percent of acreage burned on the experimental tract. This percentage is about one-third of the Regional standard. This relatively small area burned undoubtedly is a reflection of the intensive lookout and patrol system employed.

EASTERN LASSEN HAZARD REDUCTION EXPERIMENT.

INTRODUCTION

It was estimated in the plan for the Old Miner's Ditch Experiment that it would last for thirteen years. The Eastern Lassen Experiment agreement did not specify the number of years the plan would be in effect. Instead, protection was to be given the area until the interested parties agreed that the hazard had returned to normal. It is generally agreed that this time has not yet been reached. It was further agreed that the fire line system could be terminated at the close of any logging season provided the company piled and burned the slash in lieu thereof and continued the protection of the undeteriorated slash. The company requested this change in December 1932. Very little logging was done on the area in 1933. In 1934, piling and burning was the method of slash disposal employed. In 1935 the company plans to buy logs from the Red River Lumber Company. Detailed costs are available for the years 1926-1930 inclusive, which will furnish the basis for this report.

History of Development of Project

The Old Miner's Ditch hazard reduction experiment, which has been described, is located within the important timber belt which clothes the western slope of the Sierra Nevada. Timber of large size, heavy stands per acre, diversified and often steep topography, characterize that region. From Eastern Plumas County northward the Sierra Nevada loses its distinctive crest. The most striking feature of this northeastern portion of the state is a high plateau, of lava origin, from which sluggish streams flow both west to the Pacific Ocean and east to the Nevada deserts. This region, generally known to lumbermen and foresters as the Eastern Sierra pine belt, embraces considerable portions of Sierra, Plumas, Lassen, Modoc and Siskiyou Counties, and contains important forest resources from which nearly 50% of the California pine cut is at present derived. In contrast to the west slope, it is characterized by smaller timber, lighter stands per acre, uniform, relatively level topography and less precipitation. These differences in physical factors create a sufficiently distinct fire problem to justify another test of the firebreak system in that locality when opportunity offered.

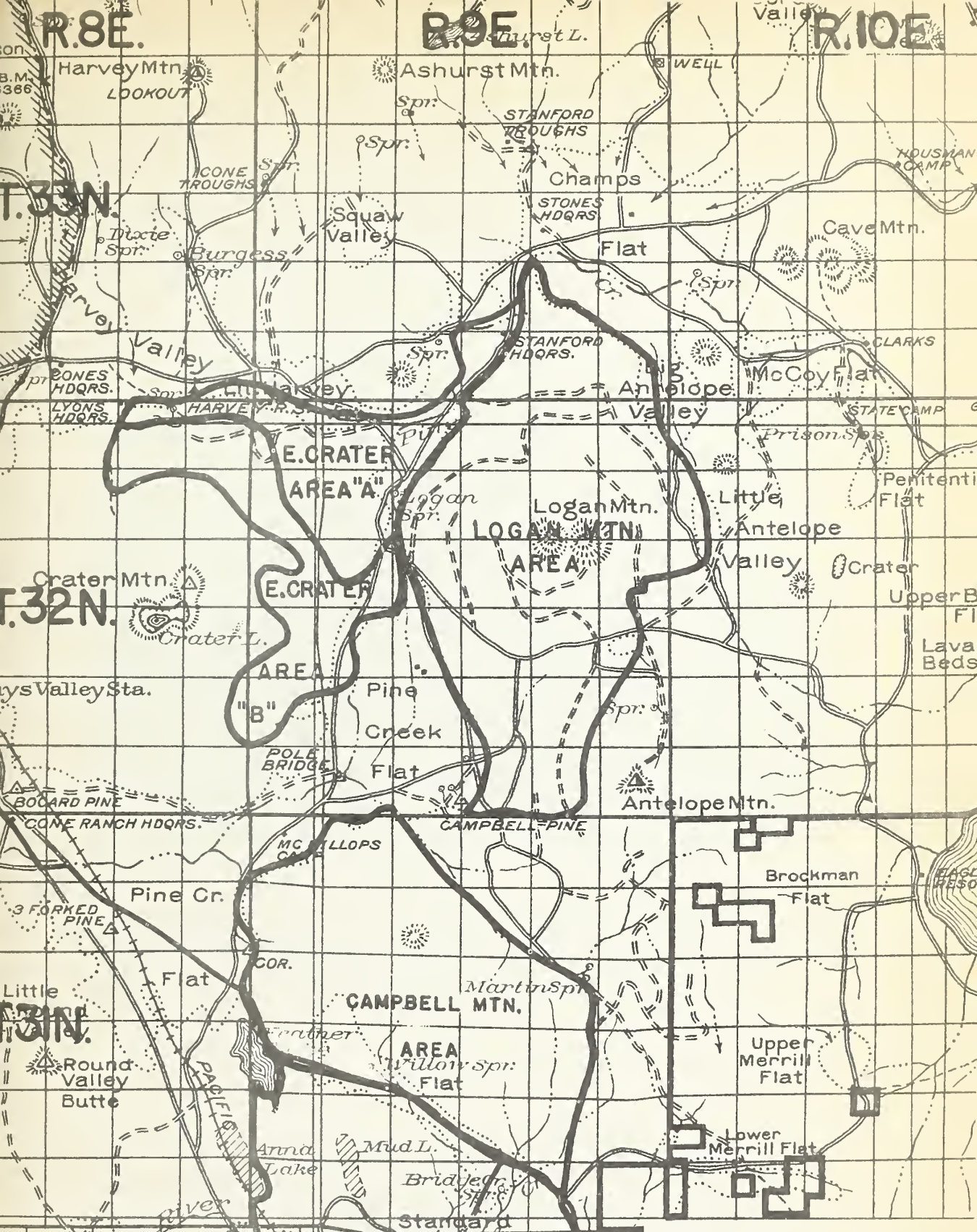
The opportunity came in 1926. The Fruit Growers Supply Company of Los Angeles,California,had acquired a timber holding of about

42,000 acres within the eastern portion of the Lassen National Forest, and had established a large four band sawmill at Susanville, California, in 1919. In 1922 the Forest Service organized the Eastern Lassen Working Circle, an area of about 229,000 acres of government land surrounding the Fruit Growers Supply Company holdings. 994,000 M feet B.M. of sawtimber on an area of about 107,000 acres within this Working Circle was advertised for sale. The Fruit Growers Supply Company's bid was accepted and a cutting contract extending to December 31, 1953 was executed by them, which provided for a limitation of cut in accord with the terms of the management plan and for disposing of slash resulting from cutting by piling and burning. The company employed a Forester and expressed the intention of handling operations on their timber lands so as to maintain their productive capacity and thus contribute to the accomplishment of the aims set forth in the Forest Service's plan of management.

Cutting operations commenced on company land in 1920. Also a small acreage of National Forest land was logged under separate sale contracts in 1920 and 1921. From the beginning of logging operations, serious damage was done by fire. Large fires occurred on company land during the seasons of 1921 and 1922, due to carelessness in brush disposal and lack of proper organization for handling fire suppression efficiently. In the summer of 1924 this series of fires culminated in a terrific 5,000 acre conflagration which swept across Antelope Mountain during a dry, windy July period. Two other damaging fires which covered 300 acres also occurred during this year. The total direct loss to the United States from these three fires amounted to approximately $92,000. In addition, the productive capacity of the fire area was seriously reduced, which has made it necessary to undertake expensive planting operations on a substantial portion. Furthermore, the Lumber Company expended a large sum (about $37,000) in fire suppression and suffered a severe indirect loss due to the disturbance of operations which resulted from the fire.

1924 was an epochal year in California fire history. Many other serious burns occurred throughout the pine timber belt of the state. As a result both public and private timberland owners were awakened to a realization of the lack of adequate preparedness in their fight against their common enemy - fire. A new fire code for application on timber sale areas was prepared by the Forest Service and a more sincere and orderly effort to prevent and suppress fire on private land has been clearly evident since that time.

Probably as a result of their unfortunate fire experience between 1920 and 1925 the Fruit Growers Supply Company submitted a comprehensive firebreak protection plan to the Forest Service in 1926, which they advocated as a substitute for the brush piling and burning practice required by their contract. In support of their plan they argued that brush piling and burning did not yield a sufficient degree of sustained fire protection to justify its cost which they had found to be about 45 cents per M, or $8 per acre up to that time.



FRUIT GROWERS SUPPLY COMPANY, LASSEN AREA

SHOWING BOUNDARY OF UNITS INVOLVED IN THE EXPERIMENT.

The recognized fact that piled brush creates a serious hazard until it can be disposed of by burning was emphasized, as well as the difficulty of complete fall brush burning without resultant damage due to uncertain weather conditions. The complete protection scheme offered as a substitute resembled the plan in effect on the Stanislaus National Forest area in general outline, except that more emphasis was placed on wider and cleaner firebreaks. Its advocates saw in it an opportunity for more enduring protection at a lesser cost.

As public travel is particularly heavy on this area signs such as the one shown above have been erected to inform the public that the area is under intensive patrol and detection.

Responsibility for the Protective Work

The Fruit Growers Supply Company initiated the project. Because this company anticipated a long term logging operation within the area on their own land and related public land, they were vitally interested in maintaining its productive capacity. Also, the company had available the necessary facilities, in both labor and equipment, for carrying on the protective work planned and for handling the suppression of fires which occurred. It was, therefore, agreed that all of the work

related to the experiment would be carried out and financed by the company just as it would have been necessary for them to have conducted the brush piling and burning operations originally required by the timber sale contract.

Area and Cut of Timber

After considerable negotiation it was agreed that the methods outlined in this plan would be put into effect, experimentally, on the Logan Mountain and Bridge Creek Units within the sale area (see map). The Logan Mountain Unit is largely public land and the Bridge Creek Unit is substantially owned by the Fruit Growers Supply Company. In 1928 the Campbell Mountain Unit, and in 1930 the East Crater Mountain Unit, both of divided ownership, were added. The experimental protection plan is available for reference in the appendix, together with modifications of the timber sale contract which were essential to the change in the protective scheme.

The approximate acreages, by ownership, involved in this fire protection experiment at the close of the year 1930, are shown in Table No. 6.

TABLE No. 6

Unit	Government Acreage	F.G.S.Co. Acreage	Other Acreage	Total
Logan Mountain	10,600	1,300	---	11,900
Bridge Creek	1,300	9,000	---	10,300
Campbell Mountain	4,100	6,400	---	10,500
East Crater Mountain				
Compartment A	1,500	700	200	2,400
Compartment B	3,300	400	40	3,740
Totals	20,800	17,800	240	38,840

Table No. 7 is based upon a cruise of 18,568 acres of cut-over National Forest land, largely located within the protection units. It shows the average original stand per acre by tree species and the results of cutting operations.

TABLE No. 7
(Volume in M.B.M.)

	Ponderosa Pine	Sugar Pine	White Fir	Incense Cedar	Lodgepole Pine	TOTAL
Cut per acre	11,730	580	3,940	390	50	16,690
Left per acre	3,170	140	2,120	90	100	5,620
Net stand per acre	14,900	720	6,060	480	150	22,310
Percent of each species cut	78.7	80.5	65	80.5	33	
Composition of total cut by species	70.3%	3.4%	23.6%	2.4%	.3%	

Several striking differences are at once apparent between this experimental area and the Old Miner's Ditch tract, viz: this area is nearly fourteen times as large, the cut per acre is but little more than one-half as great, the percentage of ponderosa pine in the cut is nearly twice as great, while the percent of sugar pine in the cut is negligible. However, the total pine percentage in the cut is almost identical. Other essential differences will be brought out in succeeding paragraphs.

Timber Types

The dominant types on the experimental area are the ponderosa pine type and the ponderosa pine-white fir type mixture, which occupy about 28% and 58% of the area, respectively. Within the prevalent sites three and four, the ponderosa pine type covers the flat and rolling land while the ponderosa pine-white fir type has taken possession of the northern and eastern exposures of the several volcanic mountains. On better sites this latter type occurs on level and rolling land, notably in the Bridge Creek drainage. A pure white fir type occurs at high elevations largely above the commercial timber belt. Two percent of the area is within this type and 12% within the lodgepole pine type. A grass and sagebrush type, irregular in outline, covers large areas of poorly drained land at low elevations.

Topography

The high plateau, which characterizes this region, has an average elevation of about 5,600 feet. Occasional, cone-shaped peaks of volcanic origin, such as Crater Mountain and Logan Mountain, rise to

elevations of from 1,500 to 2,000 feet above the general level. The lower, well drained slopes of these mountains bear the best quality of timber.

A large part of the cutting done up to the present time has taken place on south and west exposures where the fire danger is high due to prevalent southwest summer winds.

Reproduction and Undergrowth

The reproduction on this experimental area in general is satisfactory in amount, although wherever a few white fir seed trees are present in the stand, over 50% of the young growth is of this species. *Of all reproduction up to 4" D.B.H. careful studies of tractor logging damage have shown that about 27% by number is destroyed. A count of a number of small sample plots, aggregating .4 of an acre on Logan Mountain within the cutover experimental area, revealed the following survival:

Size Class	Number per Acre
Less than 2 feet high	2,020
2 feet to 5 feet high	1,090
5' to 4" d.b.h.	370
Total	3,480

A survey of a ten acre cutover plot in the same locality indicates the following stocking by area:

Size Class	Percent of Area **Fully Stocked
0 to 5' High	43.9
5' to 4" D.B.H.	19.4
Total	63.3

In addition, 113 individual young trees of the above size classes were found outside the fully stocked area.

Very little reproduction has become established since logging. The period has been short and climatic conditions have been unfavorable.

Undergrowth within the timber belt is not an important fire danger in this region. Manzanita (Artostaphylos patula) and snowbrush (Ceanothus velutinus) temporarily occupy areas of heavy burn. Squaw-carpet (Ceanothus prostratus) forms a low cover over irregular areas un-

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* Tractor Logging Damage Study - Fruit Growers Supply Company Sale Area, Lassen National Forest, December 9, 1926 by John R. Berry, Logging Engineer, Forest Service manuscript report.

** Areas were considered fully stocked within which the young trees were not over 6.6 feet apart.

der the trees. This species does not ignite readily. Frequently it checks slow burning ground fires.

Soil

The soil which bears timber is of volcanic origin. On the older lava flows it is deep and productive. The more recent flows are composed of large, irregular, jagged rocks. They intrude into the timber area sometimes forming natural fire barriers and always adding to the difficulty of logging.

Climate

This eastern Sierra plateau has a climate characterized by cold winters, wide daily fluctuations of temperature in summer, frequent summer thunder storms which are a common cause of fire, and light annual precipitation. Precipitation records kept at Westwood, a town of 4,800 feet elevation, fifteen miles south of the area in the same timber belt, show an average precipitation of 20 inches for the years 1923 to 1929. The snowfall averages 4 to 6 feet annually.

The Fire Danger

In several respects the fire danger on this area is not as great as on the west slope project. The relatively small cut per acre, about 17 M as compared to 39 M, signifies less volume of hazardous slash. Caterpillar tractors powered with internal combustion engines are used in logging very largely instead of steam donkey engines, thus decreasing the fire risk. The areas are not traversed by heavily traveled roads. Deer are plentiful, however, and many hunters visit the locality during the fall hunting season. If rains have not occurred by that time (September 15) usually the areas are closed to the public. The percentage of relatively level land is greater than on the west slope area, which tends to reduce the likelihood of rapid spread of fire. However, this favorable condition is probably offset by more constant southwest wind of higher average velocity. Moreover, the risk of lightning fires is considerably greater on this area than on the west slope area; here 16% of the fires resulted from that cause and there only 10%.

Test Period

It will be remembered that a thirteen year test period was decided upon in connection with the Old Miner's Ditch experiment on the basis of the assumption that at the end of that time the hazard on the area would have reached a normal condition comparable to that on an area where slash had been piled and burned. In this case this period is less definitely fixed. It is agreed that either the Fruit Growers Supply Company or the Forest Service may terminate the experiment by written notice at the end of any logging season. In 1933 the Fruit Growers Supply Co. took advantage of this provision and are constructing no additional fire lines. They are, however, obligated to maintain the work already done and to protect the area within the fireline system until normal hazard has been declared. While normality has not been defined in the protection plan, undoubtedly it will be judged as previously indicated by relating conditions on the experimental area to those on an area where slash has been piled and burned. In the discussions which have been held regarding this point with those experienced in fire protection it has been estimated that a period of about fifteen years after cutting would probably elapse before the desired condition of hazard would be obtained. It is anticipated that this period will be somewhat longer than on the Stanislaus National Forest area, due to slower decomposition of hazardous material because of less precipitation - particularly less snowfall.

Primary and Secondary Firebreaks

The plan of work proposed a system of primary and secondary firebreaks very similar to the proposals in connection with the west slope experiment except that the area embraced within the breaks was definitely limited to an average of 100 acres with fire trenches four feet in width, cut to mineral soil, on each side of the breaks. Approximate widths of 100 feet for primary lines and 50 feet for secondary lines were established.

On the Old Miner's Ditch area the reproduction within the firelines was not cleared. Due in part to denser stocking on the Lassen area the plan provided that stands of poles and saplings within the breaks would be thinned sufficiently to reduce the danger of fires crossing them. It was also stipulated that small trees left would be trimmed to a height of five feet, that slash and brush would be removed, or piled and burned as indicated by the Forest officer in charge, that down logs would be removed or burned, and that trees left between the fire trenches would be protected by removal of inflammable material around their bases and by careful spacing of brush piles so as to avoid damage to remaining timber when the brush was burned.

Primary fire line in Section 15 (Lassen) ponderosa pine and white fir type. Railroad spur converted into a motorway. All reproduction and poles cut and burned to reduce fire hazard.

Other Protective Measures

While the primary firebreaks are the most important feature of the protection scheme, other supplemental measures were stipulated as follows:

a. A special fire lookout with telephone communication.

b. Clearing of a few skid roads within each compartment after logging.
Special fire trails back of each setting, unless protection was afforded by a logging railroad spur.

c. Maintenance of primary and secondary firebreaks, including clearing of the lateral fire trenches every three years.

d. The felling of all dead trees immediately after logging.

e. The clearing of all motor roads throughout the area and of all railroad rights of way prior to logging.

f. Construction of protection motor roads on the railroad grades after logging and also any special roads necessary to secure a degree of accessibility satisfactory to the Forest Supervisor.

g. Compliance with the terms of a detailed fire plan designated primarily to secure prompt, well equipped and well organized attack upon all fires which occurred within the entire sale area. This plan appears in full in the appendix.

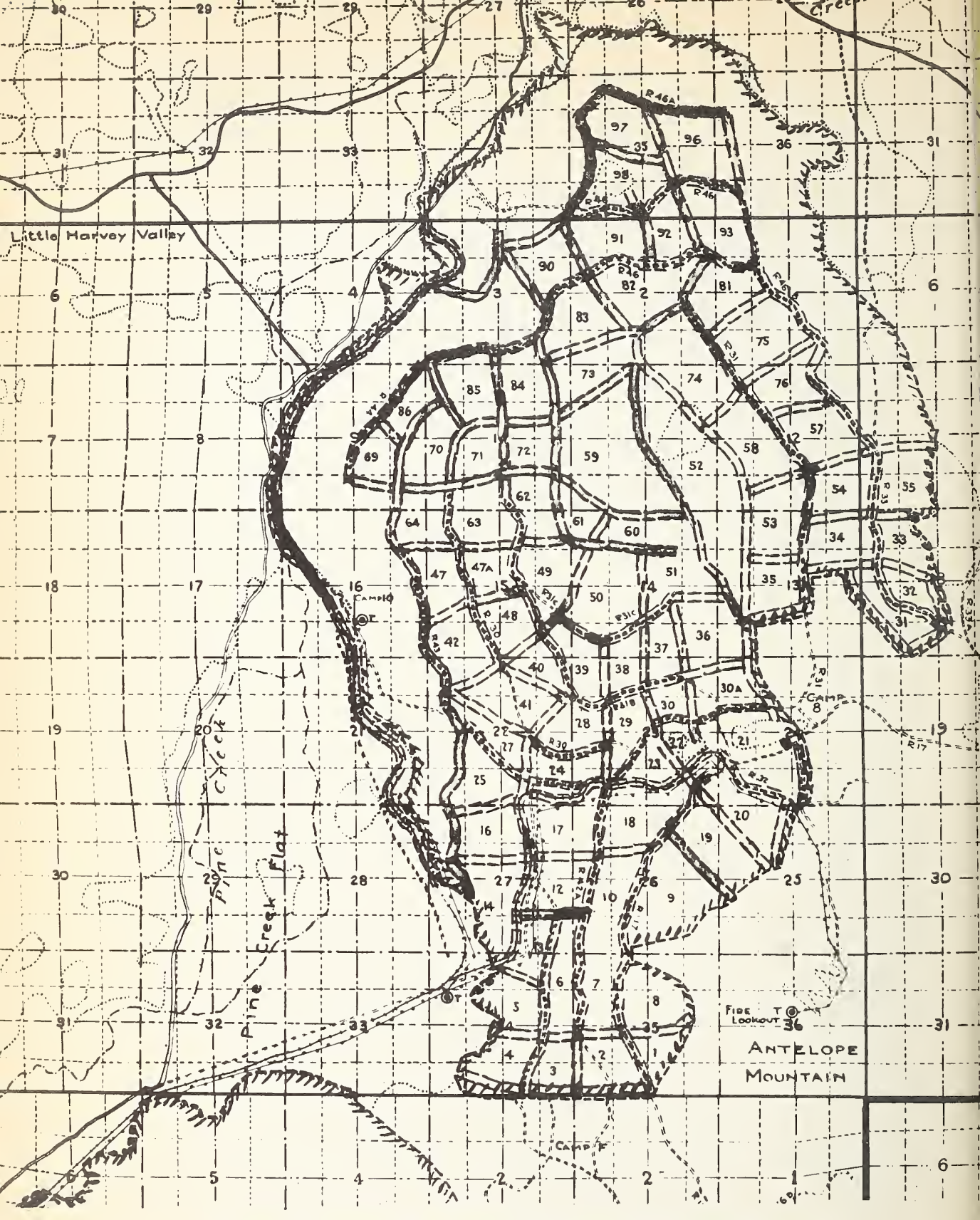
Execution of the Protective Plan

The Old Miner's Ditch experiment is not only limited as to its duration, but also the amount of money that is available for expenditure is definitely fixed. Neither of these strictures apply with similar force to this Eastern Lassen project. This approach lends desirable flexibility to the undertaking and is more in line with standard research procedure since it does not involve the hampering effect of forecasting in advance the very results for which one is searching.

In the case under discussion the methods to be followed have been defined by the cooperators. The timber operator (the Fruit Growers Supply Company) assumed the obligation of carrying out these practices in good faith. Coupled with this obligation is the opportunity to decrease the cost of the work by ingenuity and efficiency, in any way which does not threaten to decrease the productive capacity of the area. While such an arrangement between timberland owner and logging operator has evident advantages, it can only be applied successfully when both parties have a sincere interest in the welfare of the land. If such interest is lacking the contractor will slight the protective work in an effort to reduce his operating costs a few cents per M and permanent injury to the land and its crop will result.

Since 1926 when the experiment was initiated, the company's business has demanded an average annual cut of about 60,000 M feet B.M. which has necessitated logging about 4,200 acres each year. The protective work has been carried on progressively and concurrently with the advance of logging operations, first in the Bridge Creek and Logan Mountain Units 1926-1930 inclusive, next in the Campbell Mountain Unit from 1928-1930 inclusive, and later in the East Crater Mountain Unit in 1930.

The execution of the provisions of the fire protection plan is a responsibility of the Company's forester, who carries on his work under the supervision of the logging superintendent. Much credit is due both of these men for the satisfactory results which have been obtained up to the present time.



FRUIT GROWERS SUPPLY COMPANY, LASSEN AREA

SHOWING IN DETAIL THE LOCATION OF FIREBREAKS ON THE LOGAN MOUNTAIN UNIT. OTHER UNITS ARE TREATED IN A LIKE MANNER. FIGURES ARE COMPARTMENT NUMBERS.

A quite complete statistical history of the protective work done, with costs, appears in Table 12 in the Appendix. It is anticipated that, as the logging operations progress into new areas, the same general protective plan may be applied, with such modifications from time to time, as are acceptable to both parties and give promise of satisfactory protection to the land, as well as to the growing timber crop at minimum cost.

Activity Classification

The following twelve activities have been carried on within the experimental area:

Firebreak construction.
Right-of-way clearing.
Construction of special fire protection roads (motorways).
Clearing skid roads.
Maintenance of fire protection improvements.
Fire patrol and detection.
Fire suppression.
Snag disposal.
Lopping tops.
Brush piling.
Brush burning.
Supplies and equipment

These captions have been used as a basis for cost keeping and in the preparation of annual reports upon the progress of the project. Each will be discussed.

Firebreak construction

Firebreak construction consists of cutting young growth and brush species as specified in the plan of work, preparing this inflammable material for fall burning and constructing a fire trail approximately four feet wide on each side of the cleared space. These breaks are located along the railroad spurs, parallel to contours, or through the timber at right angles to contours, so as to give the desired degree of protection and maintain an average area of about 100 acres within them - 108 compartments in the Logan Mountain Unit average 106 acres in size. They are the most important single feature of the plan. In the selection of their location the Company's forester takes into account all the factors that have a bearing upon both fire danger and construction cost such as, degree of slope, exposure to prevailing wind, hazardous ground cover, including the relative volume of slash from logging operations,

presence or absence of surface rock and natural openings in the forest cover. The location is determined with a view to securing the best possible balance between effectiveness and cost. For example, on steep slopes, exposed to prevailing winds, wider and more frequent firebreaks are indicated than in more level or protected terrain. Again by a slight change in location the break may be projected through an opening in the forest, where construction is easy and cheap, instead of across a rocky area where it is difficult and expensive. After the location has been tentatively selected, the federal Forest officer in charge is given an opportunity to suggest changes. All lines parallel to contours are constructed at least 100 feet in width since they must meet the heaviest sweep of fire. With the exception of three miles of 50 foot line in the Logan Mountain Unit and $3\frac{1}{2}$ miles of 60 foot line in the Bridge Creek Unit, all lines crossing contours have been about 100 feet in width also. Neither the Forest Service nor the Company have been disposed to construct a large mileage of the secondary type of line until fire experience with the 100 foot lines has demonstrated their relative effectiveness more conclusively. It is possible that results may justify a more general use of lines of fifty or sixty foot width in the future.

Firebreak slash roughly piled preparatory to burning.

A crew of approximately 12 men under a foreman, is employed in the preparation of the firebreaks. On government land an effort is made to preserve the productive capacity of the firebreak areas in a measure, and at the same time thin the young timber sufficiently so that fires will not be likely to "crown" across them. At times the young trees to be left have been marked with paint, but usually they are designated in general terms with the responsibility for carrying out the idea placed on the man in charge of the clearing. A cruise of 225 acres within firebreaks has indicated that from 20 to 35 percent of the poles from 4" to 10", and 70% of the trees 12 inches and over D.B.H. are left within them on government land. The tendency at present, as represented by the cutting on firebreaks on National Forest land in 1930, is toward leaving less young timber, thus placing greater emphasis on the protective function of the lines. The above cruising results indicate the average condition as to percentage of young timber left rather than current practice. On the private land but little young timber is left under 16" D.B.H. Brush species are generally cut clean. On both classes of area all trees must be cut for a distance of about 15 feet on the inner edges of the break to allow for the use of a caterpillar tractor in preparing the side trenches.

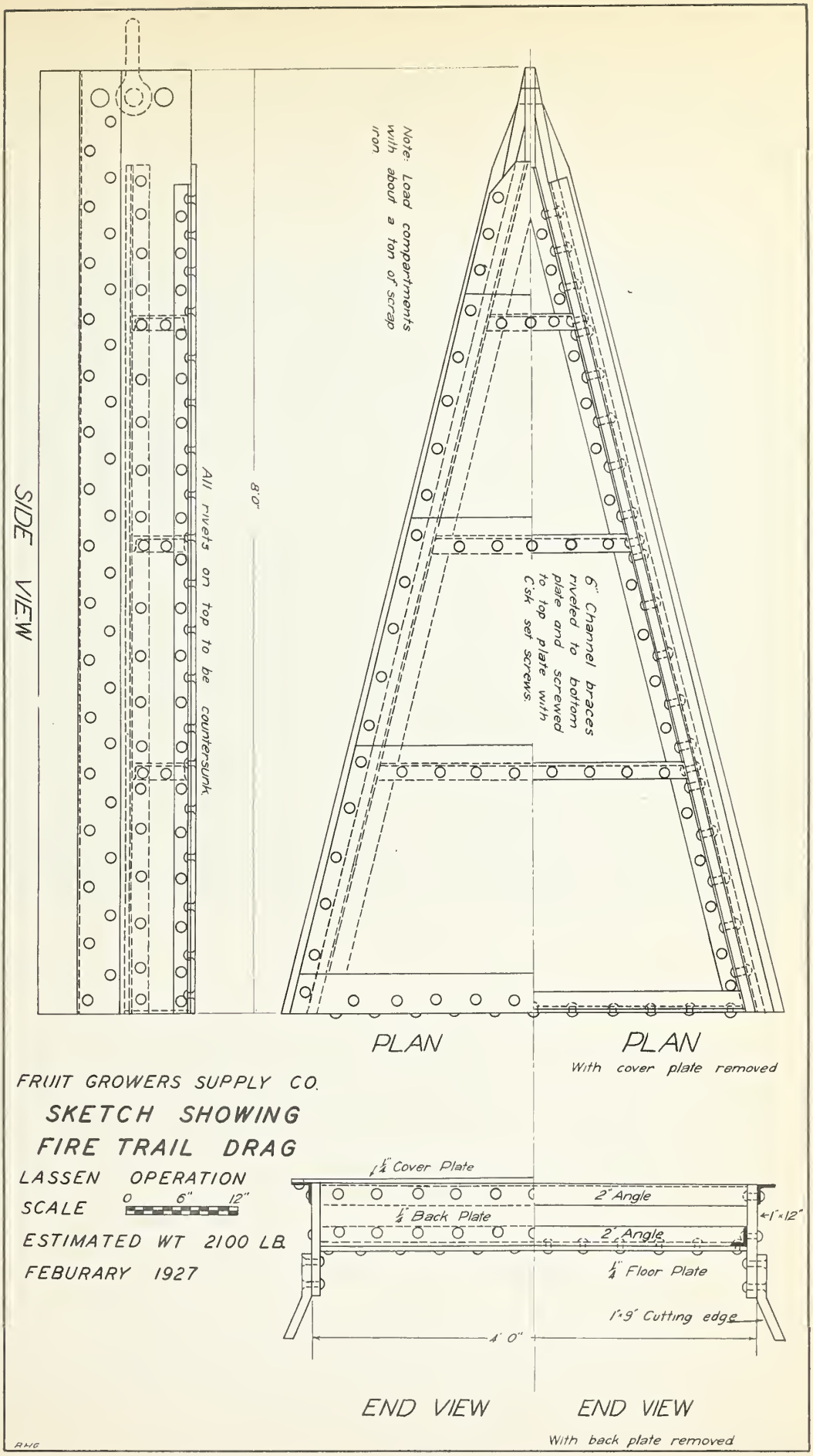
Bridge Creek Unit. Area logged in 1921. This type of clearing is representative of the Fruit Growers Supply Co. firebreaks. Less cutting was done on firebreaks on National Forest land.

All material cut on Government land is piled in heaps or windrows so spaced that no unnecessary damage will be done to young tree growth at the time of burning. On Company land this material is burned broadcast with the object of securing better fireproofing of the breaks. On both areas brush is piled over down logs which remain on the area, and burned, so as to reduce their inflammability.

The variation in treatment of the breaks as to young timber left and burning practice is an expression of a firmly grounded difference of opinion between the company and the government representatives which has been the occasion for many friendly arguments. Experience has not yet shown that the lack of clear cutting and complete ground burning within the breaks on government land seriously decreases the effectiveness of the work. On the other hand it is very clear that the acreage within the breaks on government land, amounting to about 10% of the total area, is producing more wood than the similar privately owned area. Further, counts of incoming vegetation on areas broadcast burned on company land have indicated a heavy invasion of snowbrush and manzanita seedlings; on one plot at the rate of 13,000 per acre; on another 50,000 per acre. A check with unburned areas has shown that the germination of snowbrush is accelerated fifty fold by broadcast burning. Now if these burned areas restock rapidly with brush species the effectiveness of the breaks will be threatened unless heavy maintenance expense is incurred. Accelerated brush germination does not occur to any appreciable extent where piling and burning has been practiced, probably because the seed of the brush species in the soil is destroyed by the more intense heat.

Moreover to secure a fairly complete broadcast burning of the ground surface, it is necessary to start firing early in the fall after the first rains, whereas the piled brush need not be burned until later when there is some snow on the piles which practically eliminates all risk of spread of fire. The largest fire on the area during the experimental period (20 acres) was caused by burning unpiled fireline brush in the early fall.

When all of the clearing on the firebreaks has been completed the construction of the four foot wide fire trenches on each side is undertaken. This work is accomplished with a caterpillar tractor and a triangular shaped weighted steel drag which was designed and constructed in the Company's machine shop at a cost of about $150.00. The photograph on page 42 illustrates this device and indicates the details of its construction. The trench which it constructs is very satisfactory except in excessively rocky areas. A photograph of a typical section of trench is shown on page 43 . A small amount of follow-up hand labor is necessary as a supplement to the machine work on short, difficult sections where considerable rock is present. About one-quarter mile of trench is constructed per hour by this method at a cost of about $14 per mile including caterpillar operating cost at $21 a day and depreciation at $7 a day. It is estimated by



FRUIT GROWERS SUPPLY CO.

SKETCH SHOWING

FIRE TRAIL DRAG

LASSEN OPERATION

SCALE 0 6" 12"

ESTIMATED WT 2100 LB.

FEBURARY 1927

RHG

experienced men that it would cost about $35 per mile to perform this work by hand labor.

Clearing a firebreak on the Logan Mountain Unit.

During the life of the experiment up to the termination of 1930, a total of $56,188.78 has been expended in the construction of firebreaks for the protection of 21,726 acres within them. On this basis the cost per acre protected amounts to $2.586 for the five year period. Other firebreak costs are: per linear mile $383.96; per M cut $0.163.

Right-of-Way Clearing

The right-of-way of all main line railroads and motor roads thruout the area is cleared for a distance of 30 feet on each

side of the center line, except that in the occasional case of the use of these rights-of-way for firebreaks they are cleared for a total width of 100 feet. The same methods are followed as in the clearing of firebreaks. Caterpillar tractor and drag equipment is used in preparing the side fire trenches. The cost of this trench work is the same as that shown in the discussion of firebreak construction.

The costs of right-of-way clearing are as follows: total for the period, $6,366.42; per mile $246.19; per acre protected $0.293; per M cut $0.018.

Construction of Special Fire Protection Roads (motorways).

A network of 83 miles of protection roads has been constructed thruout the area to secure satisfactory accessibility. Abandoned railroad grades have been utilized for this purpose insofar as possible but it has been necessary to construct a considerable additional mileage of rough motorway through the timber. The railroad grades are prepared for travel just as has already been described in the account of the Old Miner's Ditch experiment.

The other roads are constructed with the minimum amount of swamping and grading necessary to make them passable for motor cars at slow speeds. About three miles of such road is graded per day with tractor and grader.

The total cost of this work has amounted to $3,056.69 for the five year period equivalent to $56.94 per mile, or $0.141 per protected acre. The cost per M cut is $0.009.

Clearing Skid Roads

The skidding of logs from the woods to the landings along the railroad spurs with caterpillar tractors results in churning the soil and removing all vegetation from the log courses to a width of 10 feet or more. After logging has been completed within a setting, at least two of the widest, cleanest, and most strategically located of these skid roads are selected to serve as supplemental firebreaks. The snag fallers are instructed to keep these trails open. If it is necessary to fall a dead tree across one of them to avoid injury to young growth, then the section of this tree above the trail is bucked and rolled to one side.

Fire suppression experience on this area and elsewhere

on cutover areas has shown clearly that these cleared skid trails are of great aid in fighting slash fires. The costs of this project are as follows: Total cost, $561.20; cost per acre protected, $0.026; cost per M cut $0.002.

A 50-foot firebreak on Logan Mountain.

Maintenance of Fire Protection Improvements

This line of work consists of removal of fire hazardous material from constructed firebreaks, rights-of-way, fire protection roads and cleared skid roads from time to time when necessary to secure a uniformly satisfactory degree of fire protection from these improvements. Because this experiment was instituted only a few years ago this phase of the work has not been burdensome. Greater expenditures will undoubtedly be necessary later as natural debris accumulates upon the cleared areas and particularly within the fire trenches which border the firebreaks.

Steel fire trail drag in action.

A severe windstorm occurred on the area in 1930 which felled a large quantity of both green and dead timber on cleared areas. The removal of this material necessitated an expenditure of about $1,100 in that year, or approximately 71% of the total cost of maintenance for the period. Altogether 64 miles of special roads, 122 miles of firebreaks and 23.4 miles of rights-of-way have been recleaned. It is anticipated that the firebreak lateral trenches will have to be recleaned about every three or four years to keep them in usable condition for backfiring in fire suppression work.

Total maintenance costs amount to $1545.83 or $0.014 per acre year for the period. This is equivalent to $0.005 per M cut.

Fire trail, 2 ft. deep by 8 ft. wide, in deep soil, constructed by the caterpillar tractor and steel drag. Note large boulders dislodged and shoved aside by the drag. Also note fir tree across the line as a result of the May, 1930 windfall. Periodic removal of windfalls is an important part of the firebreak maintenance job.

Snag Disposal

In the California region the felling of dead trees (snags) on any timber area is given high priority as a hazard reduction measure by all classes of land-owners because at the

time of fire the difficulty of suppression is greatly increased by the showers of sparks and embers shed by these trees, which in severe winds, are carried for a quarter of a mile, or more, ahead of the main blaze. Since snag disposal is a definite requirement common to both the brush piling and firebreak systems of fire protection, it will not be considered in the analysis of the two systems.

On 21,283 acres of the firebreak area up to the close of 1930, 74,511 unmerchantable standing dead trees (snags), or 3.5 per acre, have been disposed of, largely by contract, at a total cost of $42,585, or 31% of the total project cost. Of these about 600 were burned in Compartment A of the Crater Mountain area. The cost of disposal per snag has amounted to $0.57; per acre $2.02.

Experiments conducted by the Forest Service and the Fruit Growers Supply Company seem to indicate that from 40% to 50% of the pine snags within the working circle can be successfully burned down during winter conditions at a cost of from 15 to 20 cents per snag. It is proposed to experiment extensively with this system in the near future as applied to uncut areas to be logged within a few years. In addition to its cheapness this method will result in the advance burning of a large volume of hazardous material which is usually left as it falls and thus adds very materially to the volume of inflammable debris which results from the cutting of the merchantable trees.

Lopping Tops

Lopping tops is defined as the cutting of green limbs from the unutilized portions of felled trees. On National Forest areas where the brush piling and burning system is practiced, it is required that all tops shall be lopped and that the limbs be piled with the other slash. This work is done by the brush pilers and not by the crew which limbs the portion of the tree to be utilized. Lopping tops was practiced on the Logan Mountain and Campbell Mountain areas from the beginning of experimental work on these areas up to the end of the 1930 season. The Fruit Growers Supply Company did not feel that this practice reduced fire hazard sufficiently to justify its cost and therefore no lopping was done on the Bridge Creek area where their ownership is heavily predominant. During the 1930 season a brief study of the value of this activity was made on the ground by a group of Forest Service experts. It was decided to discontinue this requirement except on especially designated small areas representative of unusual hazard conditions. It has been conclusively proven that the needles and small branchlets - the most inflammable portion of the tops - are shed more quickly when left exposed than when matted on the ground.

This quicker shedding seems to be due primarily to the greater degree of exposure to the elements (wind, sun, rain, snow and ice) and also to greater activity of secondary insects.

During the project, tops have been lopped on 8,237 acres at a total cost of $3,402.22, or $0.413 per acre lopped equivalent to about $0.031 per M for the timber cut from acreage lopped.

Brush Piling and Burning

Within this Eastern Lassen experimental area brush piling and burning has been employed only on the firebreaks, rights-of-way, and Crater Mountain Unit - Compartment B.

The decision to use the firebreak system on Compartment A of this unit and the piling and burning system on Compartment B was based upon the fact that the southern portion of the area allocated to Compartment B is quite exposed to the prevailing summer wind and the northern portion is too rough and rocky to allow of effective fireline construction. The treatment of those two compartments by different protective methods adapted to the conditions on the ground is expressive of a growing tendency among both public and private agencies who are at grips with fire preparedness problems.

Supplies and Equipment

The supplies and equipment cost item is a minor one in connection with this project largely because it has not been necessary to purchase any heavy expensive machinery. The automobiles and caterpillar tractors which have been used from time to time on the area were acquired for use in connection with the logging operation.

All tractor operating costs, except the cost of the annual overhauling which takes place every winter, and depreciation, are included at the rate of about $21 a day in the cost of the firebreak, right-of-way clearing and special road construction activities. Caterpillar depreciation at the rate of $7 a day is shown as a separate item in Table 5.12. The triangular steel drags, two of which are in use, cost approximately $150 each. They were charged off as of the year constructed. This treatment of this and other minor equipment items perhaps introduces a slight inaccuracy into this cost accounting at present which can be adjusted in the final report at the conclusion of the experiment by eliminating from the calculation then any equipment residual values which exist.

In addition to the equipment mentioned, a supply of shovels, axes, mattocks, McLeod or Kortick tools and Armstrong water cans with pump and hose is maintained for use in both fire suppression and in construction of fire protection improvements.

The total supplies and equipment cost for the period amount to $3,244.56, or $0.02 per acre per year. This is equivalent to $0.009 per M cut.

Fire Patrol and Detection

One patrolman has been employed for each unit from approximately May 15 to October 15 of each year except that the Bridge Creek Unit patrol has covered the Campbell Mountain Unit also. Up to 1929 horses only were used in patrolling. Since then both automobiles and horses have been used.

No regular, fixed patrol routes have been outlined. Each sub-division enclosed by firelines is numbered both on the ground and on the patrolmen's maps. The Forester, using these numbers, indicates changes in patrol routes as dictated by his judgment after taking into account fluctuating hazards and risks which affect the fire danger. Under ordinary conditions the patrolmen spend a large part of their time on call at headquarters where they are in touch with the lookout by telephone. Also they follow after the logging trains and the woodsmen as they go to and from work. Particular attention is given to detecting and reporting for removal, trees which have fallen across the firebreaks.

The company employs a special fire lookout for the purpose of detecting fires on the experimental area. This man is stationed on Antelope Mountain, a high peak just south of Logan Mountain, from about May 15 to October 15 each year. Detection service is also secured from the Forest Service lookouts on Harvey Mountain north of the area about 4 miles and from Pegleg Mountain, a few miles southward. The Antelope Mountain lookout is connected by telephone with the Fruit Growers Supply Company main logging camp now located on the lower westerly slope of Logan Mountain.

No detailed detection record has been maintained. The Company's forester reports, however, that all fires have been promptly detected and reported. The cost of this patrol and detection service amounted to a total of $8,743.13, of which about $200 was expended in constructing ten miles of tree telephone line and about $700 for a road to the lookout point, tent platform for lookout's housing, and minor incidental equipment. These investment items were charged off as of the year the improvements were constructed. Average patrol and detection cost per acre for five year period is $0.055; per M feet B.M. cut, $0.025.

TABLE NO. TWELVE

SUMMARY OF PROTECTIVE WORK DONE AND COSTS - 1926 - 1930 INCLUSIVE - EASTERN LASSEN HAZARD REDUCTION EXPERIMENT - LASSEN NATIONAL FOREST - REGION 5.

(1)	(2)	(3)		(4)				(5)					(6)					(7)			(8)		
UNIT	YEAR	ACREAGE PROTECTED BY FIREBREAKS (1) ETC.		FIREBREAKS				RIGHT OF WAY CLEARING					SPECIAL ROADS					CLEARING SKID ROADS			MAINTENANCE FIRE PROTECTION IMPROVEMENTS		
		Acres	Cut M Ft BM	Miles	Total Cost Dollars	Cost Per Mile Dollars	Cost per acre Protected Dollars	Cost per M Cut Dollars	Miles	Total Cost Dollars	Cost Per Mile Dollars	Cost Per Acre protected Dollars	Cost per M Cut Dollars	Miles	Total Cost Dollars	Cost Per Mile Dollars	Cost per Acre protected Dollars	Cost per M Cut Dollars	Total Cost Dollars	Cost per acre protected Dollars	Cost per M Cut Dollars	Total Cost Dollars	Cost per acre Affected Dollars	Cost per M Cut Dollars
Logan Mountain	Prior to and 1926	1872.5	22,166	9.88	2715.93	274.89	1.450	0.123	3.3	665.15	201.56	0.355	0.030	5	743.78	148.76	0.397	0.034	-	-	-	-	-	-
	1927	1139.	13,104	17.03	5751.69	337.74	5.050	.439	-	-	-	-	-	12	515.55	42.96	0.453	0.039	-	-	-	237.44	0.208	0.018
	1928	2255.	28,612	21.	7938.08	378.00	3.520	.277	1.5	160.52	107.01	0.071	0.006	14	451.64	32.26	0.200	0.016	213.25	0.095	0.007	44.68	0.020	0.002
	1929	4549.5	63,400	34.	13382.55	393.60	2.942	.211	2.	600.90	300.45	0.132	0.009	7	153.31	21.90	0.034	0.002	251.05	0.055	0.004	65.70	0.014	0.001
	1930	726.	11,652	7.50	3712.77	495.04	5.114	.319	2.	160.14	80.07	0.221	0.014	8	127.19	15.90	0.175	0.011	31.95	0.044	0.003	598.33	0.824	0.051
Totals & Unit Costs		10,542	138,934	89.41	33501.02	374.69	3.178	0.241	8.8	1586.71	180.31	0.151	0.011	46	1991.47	43.23	0.189	0.014	496.25	0.047	0.004	946.15	0.090	0.007
Tractor Depreciation					625.94	7.00	0.063	0.0045		64.96	7.38	0.006	0.0005		106.96	2.33	0.010	0.0014						
Bridge Creek	Prior to and 1926	4099.61	74,794	9.47	2682.25	283.24	.654	0.036	5.77	2219.49	384.66	0.541	0.030	6	172.87	28.86	0.042	0.002						
	1927	2521.78	35,373	25.4	8175.55	321.87	3.242	0.231	4.74	941.43	198.60	0.373	.027	12	362.76	30.23	0.144	.010						
	1928	703.54	13,647	9.25	4276.02	462.27	6.078	0.313	2.50	556.48	222.59	0.791	.041	8.25	202.10	24.50	0.287	.015						
	1929	-	-	-	867.95	-	-	-	-	127.58	-	-	-	-	-	-	-	-				-	-	-
	1930	-	-	3.	1442.02	480.67	-	-	-	-	-	-	-	1.50	30.07	20.05	-	-				485.12		
Totals & Unit Costs		7324.93	123,814	47.12	17443.79	370.20	2.381	0.141	13.01	3844.98	295.54	0.525	0.031	27.75	767.80	27.67	0.105	0.006				485.12	0.062	0.004
Tractor Depreciation					329.77	7.00	0.045	0.0027		96.04	7.38	0.013	0.0008		64.54	2.33	0.009	0.0005						
Campbell Mountain	Prior to and 1928	3,049	69,189	2.31	1024.08	443.33	0.336	0.015	3.55	731.71	206.12	0.240	0.011	9	104.99	11.67	0.034	0.0015						
	1929	2	32	4.50	2196.98	488.22	1,098.49		-	-	-	-	-	-	-	-	-	-	37.70	18.850	1.178			
	1930	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	114.55	-	-
Totals & Unit Costs		3,051	69,221	6.81	3221.06	472.99	1.056	0.047	3.55	731.71	206.12	0.240	0.011	9	104.99	11.67	0.034	0.0015	37.70	0.012	0.0005	114.56	0.038	0.0017
Tractor Depreciation					47.46	7.00	0.016	0.0007		26.18	7.38	0.009	0.0004		20.93	2.33	0.007	0.0003						
E.Crater Mt. Comp. A.	1930	808	12,203	3.	998.81	332.94	1.236	0.082	.50	12.15	24.30	0.015	0.001						27.25	0.033	0.002			
Tractor Depreciation					20.93	7.00	0.026			3.69	7.38	0.005	.0003											
Total (without depreciation)		21725.93	344,172 (15.8 per A)	146.34	55164.68				25.86	6175.55				82.75	2864.26				561.20			1545.83	0.071	
Tractor Deprec. (5)					1024.10					190.87					192.43				-					
Totals & Unit Costs inc.Tractor Depreo. (5 Yr. Basis)					56188.78	383.96	2.586	0.163	25.86	6366.42	246.19	0.293	0.018	82.75	3056.69	36.94	0.141	0.009	561.20	0.026	0.002	1545.83	0.071	
Average per year																							0.014	0.005
Percentage of total (exoluding Crater Mt. Comp. B)						44.9%				5.1%					2.4%				.4%			1.2%		

				BRUSH DISPOSAL									
				Acres Piled	Cost of Piling Dollars	Cost Per M Dollars	Cost per Acre Dollars	Brush Burning Acres	Cost of burning Dollars	Cost Per M Dollars	Cost Per A. Dollars		
E. Crater Mountain (Comp. B)	1930	1466 (16.8M) (Per A)	24,800	976	8427.88	0.543	8.635	806	949.07	0.073	1.18		
Grand Total, including E. Crator Mt. Comp.B.			368,972										

(1) Includes acreage protected by Right of Way Clearing, Special Roads and Clearing Skid-roads.
(2) (Estimated) Represents a few snags felled on area cut over previous year.
(3) 600 of these snags were burned on 250 acres. Cost 14 cents each.
(4) Average acreage protected for five year period.

SUMMARY OF PROTECTIVE WORK DONE AND COSTS - 1926 - 1930 INCLUSIVE - EASTERN LASSEN HAZARD REDUCTION EXPERIMENT - LASSEN NATIONAL FOREST - REGION 5.

UNIT	(9) PATROL AND DETECTION				(10) FIRE SUPPRESSION			(11) SUPPLIES AND EQUIPMENT			(12) SNAG DISPOSAL			(13) LOPPING TOPS							
	Total Cost Dollars	Acres protected	Cost per Acre protected Dollars	Cost per M Cut Dollars	Total Cost Dollars	Cost Per Acre Affected Dollars	Cost Per M Cut Dollars	Total Cost Dollars	Cost Per Acre Affected Dollars	Cost Per M Cut Dollars	Total Cost Dollars	Acreage Affected	Number Felled	Cost Per Snag Dol.	Cost Per Acre Dollars	Total Cost Dollars	Acres Affected	Cost Per Acre Lopped Dollars	Cost Per M Cut Dol.	Total costs of columns 4-5-6-7-8-9-11 Dollars	Total costs of columns 10-12-13, Fire Suppression, Snag Disposal, Lopping Tops	Grand Total Dollars
Logan Mountain	325.82	)	0.027	0.015	70.31	0.006	0.003	104.79	0.009	0.005	2225.00	1185	4190	0.531	1.878	177.20	542	0.327	0.008	4,555.47	2,472.51	
	699.50	)	0.058	0.053	74.50	0.006	0.006	206.32	0.017	0.016	3253.43	1519	5309	0.613	2.142	228.69	915	0.250	0.017	7,410.50	3,556.62	
	990.95	12,000)	0.083	0.035	631.74	0.053	0.022	301.27	0.025	0.011	5570.00	2458	9157	0.608	2.266	523.34	1221	0.429	0.018	10,100.35	6,725.08	
	815.61	)	0.068	0.013	25.81	0.002	-	869.64	0.072	0.014	9698.40	4600	21341	0.454	2.108	2011.24	4479	0.449	0.032	16,138.76	11,735.45	
	743.29	) 0.062	0.064	84.21	0.007	0.007	455.11	0.038	0.039	1247.64	875	2490	0.501	1.426	412.06	1019	0.404	0.035	5,828.78	1,743.91		
Totals & Unit Costs Tractor Depreciation	3575.17	12,000	0.298	0.026	886.57	0.074	0.006	1937.13	0.161	0.014	21994.47	10637	42487	0.518	2.068	3352.53	8176	0.410	0.024	44,033.90	26,233.57	70,267.47
Bridge Creek	672.35	)	0.055	0.009	398.51	0.033	0.005	104.78	0.009	0.001	2760.68	1115	2531	1.091	2.476					5,851.74	3,159.19	
	758.24	)	.063	.021	110.45	.009	.003	206.32	0.017	.006	7958.48	3900	12644	0.629	2.039					10,444.30	8,068.93	
	818.93	12,000)	.068	.060	53.20	.005	.004	235.86	0.020	.017	3603.72	2279.93	5755	0.626	1.581					6,089.39	3,656.92	
	487.01	)	.041	-	-	-	-	47.73	0.004	-	-	-	-	-	-					1,530.27	- - -	
	499.13	)	.042	-	-	-	-	143.92	0.012	-	32.62	(2) 11	63	0.518	2.966					2,600.26	32.62	
Totals & Unit Costs Tractor Depreciation	3235.66	12,000	0.270	.026	562.16	0.047	0.005	738.61	0.062	0.006	14355.50	7305.93	20993	0.683	1.964					26,515.96	14,917.66	41,433.62
Campbell Mountain	433.98	)	0.036		5.00	-	-	38.99	0.003	0.00	1297.55	853	1419	0.914	1.521	20.13	25	0.805	0.0003	2,333.75	1,322.68	
	439.23	12,000)	.037		8.37	0.001	-	157.53	.013		2180.56	640	3759	0.580	3.407	29.56	36	0.821	0.0004	2,831.44	2,218.49	
	435.89	)	.036		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	550.45	- - -	
Totals & Unit Costs Tractor Depreciation	1309.10	12,000	0.109	0.019	13.37	0.001	-	196.52	0.016	0.0028	3478.11	1493	5178	0.672	2.330	49.69	61	0.815	0.0007	5,715.64	3,541.17	9,256.31
E. Crater Mt. Comp. A. Tractor Depreciation	623.20	2,400	0.260	0.051	107.59	0.045	0.009				1157.07	808	(3)2777	0.417	1.432					1,661.41	1,264.66	2,926.07
Total (without depreciation)	8743.13	(4) 31,680			1569.69			2872.26			40977.15	20243.93	71435			3402.22	8237			77,926.91	45,957.06	123,883.97
(5) Tractor Deprec.																				1,407.40		
Totals & Unit Costs inc. Tractor Deprec. (5 Yr. Basis)	8743.13	31,680	0.276	0.025	1569.69	0.050	0.005	2872.26	0.091	0.008	40977.15	20243.93	71435	0.574	(6) 2.024 (For M $0.119)			0.413	(6) .010	79,334.31		125,291.37
			0.055	0.025		0.010	0.005		0.018	.008												
Average per year Percentage of total (exoluding Crater Mt. Comp. B)	7.0%				1.3%			2.3%			32.7%					2.7	100%					
E. Crater Mountain (Comp. B)		3,740						372.30	0.100	.020	1599.85	1039	3076	0.520	1.48					9,749.25	1,599.85	11,349.10
Grand Total, including E. Crater Mt. Comp. B.		32,428						3244.56	0.100	0.009	42585.00	21282.93	74511	0.571	2.001					89,083.56	47,556.91	136,640.47

(5) Caterpillar tractor depreciation calculated at $7 a day. Cost of tractor driver's wages, operating supplies and repairs included in activity costs. Tractor and drag construct about 2 miles of fire trench a day on firebreak and right of way clearing work, and do about 3 miles a day of special road work.

(6) Cost per M for snag disposal and lopping tops on basis M feet actually affected $0.128 - $0.031, respectively.

All units but Crater Mt. Comp. B.
All costs per acre except columns 9,10,11 - $ 5.497 per M .326
Cost per acre columns 9,10,11 - .083 per M .038
Total $ 5.580 $ .364

Results of Protection

An average of approximately 32,000 acres has been included within this hazard reduction experiment during the period under consideration. (31,680 acres, exclusive of Crater Mountain Unit, Compartment B - 32,428 acres if this compartment is included). Table 3 shows that a total of 58 fires have occurred during this time.

Causes of Fires

Thirty-seven fires, or 63.8%, have been caused by factors connected with the lumbering operation. On the Old Miner's Ditch area 72.4% of all fires which occurred during the operation period were due to this cause. Burning firebreaks caused 12 fires; smoking, seven; locomotives and loading engines, six each. Twenty-one fires or 36.2%, are not known to have been related to the lumbering operation - lightning caused nine of these (15.6% of all fires), thus demonstrating its importance as a fire factor in this locality.

The fact that the largest number of fires (12 fires, or 21%) was due to burning the firebreaks, should be particularly noted since it indicates that risk of starting fire accompanies the firebreak system of protection, as well as the piling and burning system. The Fruit Growers Supply Company advocates the surface burning of firebreaks without brush piling. If this method is followed the burning must be done early in the fall before the fire season has closed, or the slash will become too wet to burn. Well piled brush, on the other hand, sheds precipitation and may be burned under snow at a time when there is but little opportunity for fire to spread. 16,000 acres of well piled brush has been carefully burned during the period between 1918 and 1930 on a large National Forest sale a few miles south of the territory under discussion. Only one fire has escaped from this burning. This fire covered about three acres only -- a negligible percentage of the area. This record certainly indicates that if the burning of piled brush is properly timed and executed this activity does not cause fires. It seems evident that when fires result from this work usually the fault is not with the system but with those who are doing the work.

TABLE No.8

NUMBER AND CAUSES OF FIRES, 1926-1930 Incl.(By Units)

Unit and Year	CAUSES RELATED TO LUMBERING							OTHER CAUSES			
	Brush Burning	Careless-ness	Caterpillar Tractors	Locomotives	Loading Engines or Cranes	Car Brake Shoe	Smoking	Hunters and Campers	Lightning	Unknown	Total
Logan Mt											
1926	-	1	1	-	1	-	1	-	1	-	5
1927	1	-	-	1	2	-	2	-	-	-	6
1928	6	-	-	1	-	-	-	-	3	2	12
1929	-	1	-	1	-	1	-	-	-	-	3
1930	3	-	-	-	-	-	-	-	-	-	3
TOTAL	10	2	1	3	3	1	3	-	4	2	29
Bridge Creek											
1926	2	-	-	1	1	-	1	2	1	2	10
1927	-	-	-	-	-	-	1	2	1	-	4
1928	-	-	1	2	1	-	-	-	1	2	7
TOTAL	2	-	1	3	2	-	2	4	3	4	21
Cambell Mountain											
1928	-	-	-	-	-	-	-	1	1	-	2
1929	-	-	-	-	-	-	-	-	1	-	1
TOTAL	-	-	-	-	-	-	-	1	2	-	3
Crater Mountain											
1930	-	-	1	-	1	-	2	-	-	1	5
TOTAL	-	-	1	-	1	-	2	-	-	1	5
GRAND TOT	12	2	3	6	6	1	7	5	9	7	*58
	20.7%	3.4%	5.2%	10.4%	10.4%	1.7%	12%	8.6%	15.6%	12%	100%

*37 fires, or 63.8 percent caused by logging equipment and personnel.

21 fires, or 36.2 percent caused by other than operation causes.

Acreage Burned

The following table shows the acreage burned by fire causes:

TABLE No. 9

Cause of Fire	Acres Burned
Brush burning	36.00
Lightning	4.50
Unknown	3.25
Carelessness	2.25
Smoking	1.75
Hunters and Campers	1.50
Loading Engine and Crane	1.25
Locomotives	1.00
Tractors	0.75
Car Brake Shoe	0.25
	52.50 Acres

The largest fire that has occurred covered 20 acres. It resulted from burning firebreaks on a windy October day in 1926 on the Bridge Creek Unit. No other fire exceeded three acres in size. The average fire is .95 of an acre as compared to .7 of an acre on the Old Miner's Ditch area and three acres within the area of piled and burned brush on the ten National Forests previously referred to. The average acreage burned per year for the five year period is 10.5 acres, or .033% of the average project acreage (32,000 acres). This is approximately one-sixth of the regional standard of .2 of 1% and almost exactly one-half of the percentage (.058 of 1%) of area burned annually on the Old Miner's Ditch area. The fire damage which resulted from these 58 fires has not been appraised. It is known to be negligible.

Fire Suppression

The Fruit Growers Supply Company is responsible for the suppression of all fires within the sale area, or one mile from its boundaries. The timber sale agreement provides for the observance of the terms of a fire plan which is directed toward securing complete fire preparedness. This plan deals with reduction of fire hazards, fire prevention measures, fire fighting equipment and action to be taken in case of fire. For fire suppression purposes, water tank cars, steam force pumps on log loaders, water pack cans, fire fighting tool caches and adequate transportation facilities are required. The Company's organization for fire suppression is as follows:

Forester, in general charge of fire (with adequate crew leaders for assignment).

a. Bull-buck in charge of fallers, buckers and limbers- 30-60 men.

b. Swamping boss in charge of swamping gang, 10-20 men.

c. Foremen in charge of loader crew, choker setters and tractor drivers - about 25 men.

At the time of fire the above crews are called upon by the forester as needed, in the order which will interfere least with the flow of logs from woods to mill, i.e., first, the swamping crew, then fallers, buckers, limbers, and last, the log loading crew.

No exact records of get-away time, travel time, control time, or hour control, are available. Mr. Walter B. Denton, the Company's forester, states that the reports from the lookout have been uniformly prompt, that get-away time has never exceeded 15 minutes, and that all fires have been under control by the first night. He estimates that 75% of the area is within a 30-minute control zone and the remainder within a 45-minute zone.

The Company's fire organization has functioned promptly and effectively on all fires that have occurred as best evidenced by the very small acreage burned. All Forest officers assigned to the sale are instructed to assist fully in all phases of fire work.

No severe mid-fire season test of the effectiveness of the firebreaks as an aid in fire suppression has as yet occurred. They have been very helpful in two instances, however, which are reported as follows in the Company Forester's annual report for the 1928 season: "Do fire lanes as constructed on the Lassen operation materially aid in fire suppression? Our answer is that they do. To date we have two specific instances where the fire lanes not only helped, but actually stopped small conflagrations, which, without the fire lanes, would have become serious conflagrations. On October 9, 1926, a heavy southwest wind caused sparks to jump from a fire lane which had been burned two days previously. Directly in the path of the fire and at right angles to it was another lane which had been burned a week earlier. At the time of the outbreak of this fire a terrible wind from the southwest made it necessary to discontinue logging operations for the day. The entire logging crew was then organized to suppress this serious outbreak. Men were stationed on the fire lane and behind it with instructions to put out all spot fires that started. In this way the fire burned up to the fire lane and then burned out for the lack of further fuel. The flanks were trailed by hand.

On May 26, 1928, another outbreak occurred in a similar manner. The road into Camp 8 was trailed and burned and approximately

one week later (May 26) a heavy wind arose and carried sparks across. A serious fire soon started making control and attack with six men futile. The men then dropped back to the next fire lane and there stationed themselves in such a manner as to be able to pick up and put out all spot fires that started across the second fire lane. The main fire then burned up to this line of defense and then went out.

We believe from these two experiences and actual proof on the ground that fire lines in cutover areas afford a means of protection that is entirely lacking in the complete brush-piling method. A real test would be a conflagration similar to that of 1924, but we are earnestly endeavoring to overcome such disasters with an efficient protective organization and using fire lanes as a last resort".

The cost of fire suppression work follows:

Total cost	$ 1,569.69
Cost per fire.	$ 27.06
Cost per acre burned . . .	$ 29.89
Cost per acre per year . .	$ 0.001
Cost per M cut..	$ 0.005

SUMMARY

EASTERN LASSEN HAZARD REDUCTION EXPERIMENT

About 50 percent of the pine cut in California is secured from the forests of the northeastern part of the State. Reduction of slash hazard on cutting areas in this region is essential to fire control and fire control is essential to the continued cropping of the forests.

In order to test thoroughly a method of firebreak control of slash hazard, the Fruit Growers Supply Company, and the United States Forest Service entered into an agreement to use this method on two large cutting areas, one owned largely by the Company, and the other by the Government. The timber on the federal area is under sale contract to the Fruit Growers Supply Company. By the end of the 1930 logging season, a total of 38,840 acres, about equally divided between the two classes of ownership, had been placed under firebreaks.

The typical firebreak in use is about 100 feet in width, although some secondary breaks, running across contours were employed. Pole and sapling stands within the breaks were thinned sufficiently to reduce the danger of fires crossing them. Small trees left were pruned to a height of 5 feet. Slash within the breaks was piled and burned; trenches to mineral soil were constructed on each side of the breaks, and a fire lookout and telephone system were provided, as well as a system of roads and motorways. All protective work on the experiment was done by the Fruit Growers Supply Company. This was handled progressively at the rate of about 4,200 acres per year.

Twelve separate activites, for each of which costs were kept, are involved in this experiment. These are as follows:

(1) Firebreak construction.
(2) Right-of-way clearing.
(3) Construction of special fire protection roads (motorways).
(4) Clearing skid roads.
(5) Maintenance of fire protection improvements.

(6) Fire patrol and detection.
(7) Fire suppression.
(8) Snag disposal.
(9) Lopping tops.
(10) Brush piling.
(11) Brush burning.
(12) Supplies and equipment.

From 1926 to 1930 inclusive, there have been 58 fires which burned a total of 52.5 acres. The largest of these, which resulted from burning a firebreak on a windy fall day, covered 20 acres. Sixty-four percent of these fires were attributable to the lumbering operation. Lightning was responsible for almost half of those not chargeable to the operation. The damage from all these fires is known to be negligible.

No severe test of the effectiveness of the firebreaks has as yet occurred during the height of a fire season. In at least two instances they have been very helpful in stopping fires which might otherwise have developed into serious conflagrations. The total cost of fire suppression from 1926 to 1930 was $1,570, or about $30 per acre burned.

An analysis of the costs of this firebreak protection system for the period 1926 to 1930, together with the estimated costs of maintenance of the firebreaks until the return of normal fire hazard conditions, shows a total of about $4.57 per acre, or $0.29 per M feet B.M. for the timber cut from the area comprised in this experiment. It is estimated that the usual method of brush disposal on this same area would have cost $7.90 per acre, or $0.50 per M feet B.M.

APPENDIX

STANISLAUS EXPERIMENT

(Old Miner's Ditch)

HISTORY OF FIREBREAK CONSTRUCTION

In 1923, a strip 100 feet wide was cleared and burned along the upper side of the railroad from the southern boundary of the sale area to Camp Bumblebee, a distance of 2.4 miles. A similar clearing was made along the upper side of the spur from Camp Bumbleebee to the vicinity of Strawberry Peak. A total of 4 miles of clearing and burning was done during this year. (See accompanying map of area for location of fire lines). During 1924, two men were employed in constructing the fireline along the railroad spur located west of Camp Bumblebee as far north as the crossing of Cow Creek (2.7 miles). The mainline railroad was also firelined from Bumblebee to Cow Creek in that year, as well as the portion of the easterly highline railroad spur between Cow Creek and the work of the previous year (2.6 miles). The 1925 work was confined to the northern part of the area along the mainline from Cow Creek to its termination just south of Lily Creek (1.73 miles). The clearing of the railroad spurs was completed in 1926 by the construction of firebreaks along the right-of-way between Cow Creek and Dry Lake and other short sections amounting to a total of 2.3 miles. Firebreak work in 1927 consisted of clearing and burning 2.6 miles of line 50 feet wide along the lower edge of the area from Hell's Half Acre trail south to a rock slide in Section 18, which constituted a natural fire barrier. Also, a narrow fireline was cleared along that portion of the Hell's Half Acre trail within the area by raking needles and other inflammable trash away from the tread of the trail ($2\frac{1}{4}$ miles). In 1928, a firebreak was constructed along Strawberry Ridge from the Sonora-Mono highway southwest to Strawberry Peak (2.2 miles). While this break is of value in the protection of the experimental slash area, it was built largely to protect an adjacent area, and the cost of its construction, therefore, was not charged to this protection project. During the same year, a short motorway was constructed from a point near the Cow Creek Ranger Station to join the railroad grade near Camp Cow Creek.

COST COMPARISON OF BRUSH PILING AND BURNING AND FIREBREAK SYSTEM OF PROTECTION.

Even during normal economic conditions high cost of any forest protection system means limited use of such a system, particularly on privately owned land. On the other hand, a low cost system of protection, if it gives reasonably good results, is readily adopted and generally used. This cost factor is of more than usual importance in the depressed condition of the lumber industry which prevails at present. Competition in this industry is unusually severe and as a consequence all costs not absolutely essential to the production of lumber are being subjected to very close scrutiny. Forest protection is sometimes regarded, unwisely, as a cost element of this type.

Table No. 2 indicates that during the thirteen year period $29,046 has been expended on fire protection measures on this study area. If the brush had been piled and burned at a cost of 45 cents per M on the experimental area of 2,700 acres, from which a cut of 105,366 M board feet was derived, it would have been necessary to expend a total sum of $47,414.70 on this work during the cutting period from 1923 to 1927 inclusive. If we assume that the same amount of timber was cut each year during the five year cutting period, then the cost of brush disposal each year would have amounted to $9,482.94. By compounding annually these brush disposal costs from the year invested through the year 1935 at a 4% interest rate, we derive a total investment amounting to $73,110.95. Column 20 in Table No. 2 indicates the annual costs of the firebreak experiment for the years 1923-35 inclusive. These costs have been compounded on the same basis as the brush disposal costs. A total of $41,849.86 is derived. As of 1935, therefore, the capitalized cost of the firebreak system is a little more than one-half the cost of the brush disposal system.

The above comparison has been brought out here for the benefit of those who insist upon the capitalization of fire protection investments.

[2]Show, and others who have written on the subject, have shown that it is not logical to capitalize and compound investments in fire protection. Fire protection is an essential part of any long term forestry undertaking. Therefore, sums spent in this activity, and particularly expenditures related to the harvesting of the forest crop such as slash disposal, should be charged as annual costs and written off in the same manner as logging costs are handled.

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[2]United States Department of Agriculture Bulletin #1402 - "Timber Growing and Logging Practice in the California Pine Region" by S. B. Show, Silviculturist, Pages 55 and 56.

A truer cost comparison of these two systems of protection may be derived by depreciating the investment items shown in Table 2 over their full period of usefulness by the straight line depreciation method and comparing the sum of this depreciation plus annual charges with the cost of brush piling and burning. On this basis firebreak system costs are 23.9 cents per M, or $9.35 per acre. Comparable costs for the brush piling system are 45 cents per M, or $17.37 per acre.

The high cost per acre of brush piling and burning is very largely due to the heavy cut derived from the area. The cost per acre of the protective firebreak system is influenced by the small size of the area and the intensiveness of the protection furnished. The lookout and patrol systems installed doubtless could have served an area of about three times this size (2,700 acres) with a satisfactory degree of effectiveness.

Relatively high fire protection costs for this area can be justified on the basis of the high quality of the site for timber production, the high fire danger on the area, and the value of the experimental results.

Studies have shown clearly that this area is a high site quality capable of producing a large volume of wood annually. The stand cut from the area was heavy (38.6 M per acre) and of high quality. In addition about 9 M feet B.M. of thrifty timber was left after cutting to furnish seed and a basis for a second cutting in 40 or 50 years. Periodic measurements on similar cutover areas in this vicinity made by the California Forest Experiment Station indicate that the timber left is growing at the rate of 2% a year. About 180 feet B.M. per acre per year, net growth, then, is being produced immediately after cutting worth at least 66 cents on the basis of prevailing stumpage prices in the locality which averages $3.66 per M for all species. On this basis during the years 1923 to 1935 inclusive about $8.58 worth of wood has been produced per acre. It is evident that the value of wood produced on the area is equivalent to 91% of the firebreak system protection cost, which was shown to be $9.35 per acre. [3] Yield tables for second growth sugar pine, ponderosa pine and white fir, Site I stands, such as this area is capable of producing, indicate a yield of 40,100 board feet in 50 years by the International rule, or a mean annual increment of 802 board feet. The high productive capacity of the area, therefore, clearly justifies intensive protection.

The actual average annual growth attained over a rotation

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[3] Unpublished report, California Forest Experiment Station.

period under complete fire exclusion, should approach the figures indicated by the yield studies. The current annual growth for a short period after logging and in a strongly marked dry cycle, is far from a picture of the productive capacity of the site over a long period of years such as a rotation.

The high fire danger on the area has already been fully discussed. The forests of California contain 275 billion feet of standing timber. Only two states, Washington and Oregon, have more. The national importance of maintaining the productive capacity of California timber lands as they are cut over is, therefore, readily apparent. That this was not done in other once heavily timbered states is now a matter of civic regret.

For the purpose of applying the results of this study to the solution of similar protection problems on cutover areas, we may assume that if other factors are the same the cut of timber per acre in types similar to the one under consideration is expressive of the productive capacity of the area and the slash hazard which will result from cutting. Protection costs then will vary directly with the volume of the timber yield. Therefore, if 23.9 cents per M B.M. during a slash hazard period of 13 years is a sufficient expenditure for protection in a stand of timber which yields a cut of 38.6 M per acre, then in a similar stand of lower site quality yielding a cut of 25 M feet per acre an expenditure of 15.4 cents per M B.M. for the same period should be sufficient to guarantee a commensurate degree of protection. (23.9 : 38.6 :: x : 25).

It should be borne in mind that after the hazard on the cutting area has returned to normal the special fire protection will be discontinued and the cost of protection of large areas will drop to about 5 cents per acre year, or the average cost of the blanket protection in effect on all National Forest lands. This expenditure, if well planned, should result in restricting the area burned over to between .2 and .3 of 1%. Annual losses no larger than this are not inconsistent with sustained timber production. In 1930 the cost of fire protection in U.S. Forest Service, Region 5, including the cost of protective improvements, amounted to slightly over 5 cents per acre. The average percentage of forest land burned for the period 1928 to 1930 inclusive, involving one exceptionally unfavorable fire year, amounted to 0.46%.

EFFECT OF FIREBREAK SYSTEM ON FOREST GROWTH CONTRASTED WITH EFFECT OF PILING AND BURNING SYSTEM

Land owners who are consciously managing their forest areas for maximum wood production must concern themselves with the effect of any fire protection system upon young forest growth, as well as with the cost of the system.

The firebreak system employed in this experiment has already been described on Page 9 . It is very similar to the partial piling and burning system outlined by Munger and Westveld.[4]

Information secured on typical timber sale areas adjacent to this experimental tract by the [5]California Forest & Range Experiment Station shows that the disposal of piled brush has resulted, on the average, in burning the ground surface of between 6% and 7% of the areas studied. This relates to the area directly beneath the piles. In addition it is necessary to consider the area immediately surrounding the piles which is affected by the heat of burning them. In 1926 some information was secured on this point through the experimental burning of brush piles on the Herring Creek sale area on the Stanislaus National Forest. This area joins the Old Miner's Ditch sale area on the east and is very similar to it. Eight brush piles were studied of an average height of 5.7 feet and average diameter of 9.4 feet. In accordance with Forest Service standard brush piling practice in this Region, no limbs of over 4 inch average diameter were included in any of the piles. The area immediately surrounding each pile was divided into two zones and all reproduction within these zones was counted and classified according to the degree of damage done by the burning. The first zone consisted of the area within ten feet of the outer surface of the brush piles, and the second zone included the area outside the first for an additional radial distance of ten feet.

The eight brush piles were burned at the usual season, using standard methods of burning ordinarily employed in this work.[6] After this had been done the damage which resulted within each zone was recorded by degree of injury, using the following symbols: (SD) slightly damaged, (SJ) severely damaged and (K) killed. Table No. 10 indicates the extent of injury.

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[4]See P. 37, 38, 39 - Technical Bulletin No. 259, U.S.Dept.of Agriculture series. "Slash Disposal in the Western Yellow Pine Forests of Oregon and Washington" by Thornton T. Munger and R. H. Westveld.

[5]Manuscript report of California Forest & Range Experiment Station.

[6]For full description of methods of brush piling and burning see Page 50-57, Technical Bulletin No. 259, U.S.Dept. of Agriculture series "Slash Disposal in Western Yellow Pine Forests of Oregon and Washington" by Thornton T. Munger and R. H. Westveld.

TABLE No. 10

Zone	Number of Young Trees present	Slightly Damaged	Severely Damaged	Killed
1	824	28	11	12
2	940	-	-	1
TOTAL	1764	28	11	13
Percent of Total		1.6	.6	.7

These results indicate that .7% of the reproduction included within the zones was killed, .6% severely injured and 1.6% slightly injured by the burning. Without doubt a part of the reproduction included in the last two classifications died as a direct or indirect result of the fire injury. It appears conservative to assume that at least a 1% loss of young growth resulted within the zones due to the burning.

The area covered by the average brush pile studied amounted to 69.4 sq. ft. The area in Zones 1 and 2, around each pile within which there was a 1% loss of young growth, amounted to 1,848 sq. ft. By assuming that the loss of young growth is proportional to area involved, we may derive the total affected by the burning. One percent of 1,848 sq. ft., or 18.48 sq. ft., is 26.6% of the area of 69.4 sq. ft. under the average pile. It has been shown that research results indicate that about 6½% of sale areas have been burned under brush piles. The damage done in the area immediately surrounding these piles is evidently sufficient to raise this burned area percentage to approximately 8%. On this basis 304 acres of the total of 3,800 acres, including in this instance the 1,100 acres of piled brush which was partially protected by the firebreaks, would have been burned over if the method of brush piling and burning had been followed throughout the entire area. Munger and Westveld show from a study of 15 plots in piled and burned slash in Oregon and Washington that the area of reproduction killed by brush burning averaged 4.6 percent and that from 2.8 to 28 percent of the forest floor was burned over, averaging 9.4%[7]. This percentage of forest area burned checks closely with the 8% derived in connection with the Herring Creek sale area and California Forest & Range Experiment Station studies.

Of the 304 acres burned in connection with slash disposal, only about 25% is rendered temporarily unfit to support tree life. This is the area located directly under the central portion of the brush piles where the heat generated by burning is most intense. Even this area is very soon occupied by the roots of surrounding young trees, and therefore, cannot be regarded as unproductive.

The firebreak system of protection involved the piling and burning of brush on a fraction of the area represented by strips of various widths, so located as to facilitate fire suppression.

[7] Technical Bulletin No. 259, P. 29, "Slash Disposal in the Western Yellow Pine Forests of Oregon and Washington" by Thornton T. Munger and R. H. Westveld.

The strips, which contain a total area of 229.4 acres, are described in detail in Table 3. Within this area of about 230 acres, only the 29 acres devoted to protection roads can be regarded as having been taken out of production for any appreciable period. It seems probably that these roads will be used during a 50-year cutting cycle.

This experimental area is a site of the highest quality (Site I). Yield tables prepared by the California Forest and Range Experiment Station for this type and site on the basis of International Rule utilization indicate stands of 40,100 board feet per acre in 50 years. A mean annual increment of 802 board feet per acre (See P. 58). This area of 29 acres is then capable of producing 1,163,000 board feet during the cutting cycle. If we assume a present day stumpage value of $3.66 per M for this second growth material (the price received for the material cut from the area between 1922 and 1927), then it will be worth slightly over $4,000 at the end of the cutting cycle. This sum discounted for a period of fifty years at an interest rate of 4%, gives a present value of $563.00. This is a debit charge against the firebreak system.

Piled brush. Photograph taken in July, 1923. (See following picture).

Photograph taken September, 1928 of the same piled brush. Note the extent of the disintegration of the brush pile in the foreground and the development of the reproduction during the five year period.

EFFECT OF SLASH ON SOIL

No new information bearing directly on the effect of slash on soil was secured in connection with this experiment. Munger [8] and Westveld conclude that the leaving of slash affects the soil favorably, because the products of slash decomposition increase both the friability of the soil and its water absorbing capacity, and because slash is a deterrent to erosion, particularly on steep slopes.

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[8] Technical Bulletin No. 259, P. 16 "Slash Disposal in the Western Yellow Pine Forests of Oregon and Washington" by Thornton T. Munger, Director, Pacific Coast Northwest Forest Experiment Station and R. H. Westveld, formerly Assistant Silviculturist, Branch of Research, Forest Service.

Where this method of disposal was followed, 85.8% of the slash was piled and burned on areas involved in this experiment. In addition to the large volume of undisposed waste from live trees cut, in the form of material over 4" in diameter, there is always present, after slash has been piled and burned, dead and down timber and a considerable bulk of ground cover in the form of needles, leaves of deciduous trees and shrubs, twigs less than two inches in diameter, as well as products of herbaceous vegetation. In the recent past, foresters with European experience, and others unfamiliar with conditions in the California pineries after slash has been disposed of by piling and burning, have attempted to show that the use of this system of hazard reduction would lead, in time, to appreciable soil deterioration. For over a quarter of a century, the senior author has been intimately connected with the supervision of timber cutting operations on the National Forest areas in these pineries. The opinion, formed during this period, that slash disposal, as there practiced, is not injurious to soils, is amply supported by the data secured in connection with this experiment which indicates an abundance of fertilizing material left.

The pine belt of California, within which logging operations are being conducted, is situated at elevations of from 3500 to 6500 feet. At these elevations a very large part of the precipitation is in the form of snow, which does not cause an appreciable amount of erosion. Also, the soil on the area studied is of granitic origin, which is less subject to erosion damage than heavier soils. No erosion damage was found on the area, although deep gullies were cut throughout the area by the yarding of the logs, which often start erosion under less favorable circumstances. On several timber sale areas, slash has been thrown into these gullies to observe the effect of this practice as an erosion deterrent. The results have been largely neutral. Certainly the benefits are insufficient, on areas of granitic soil, to justify the fire hazard which would result from this slash disposal practice if it should be generally adopted. There are always plenty of the less inflammable limbs over 4" in diameter present for experimental use in erosion control.

EFFECT OF FUNGI UPON SLASH

Observations on the breaking down of slash, with particular reference to the part played by decay, were begun on the Stanislaus National Forest on the Old Miner's Ditch experimental area by the office of Forest Pathology in 1923 and on the Lassen National Forest in 1927 with examinations at annual or biennial intervals since. On the Stanislaus National Forest, a number of

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[9]Information large supplied by Willis W. Wagener, Pathologist, Office of Forest Pathology, Bureau of Plant Industry, San Francisco, California.

sample areas of scattered slash have been studied, as well as some larger logs and tops. In addition, 158 piles of different types and species composition were erected to learn whether aggregating slash by this means would hasten or retard decay. Of these, 138 piles are still usable. On the Lassen area, 1850 feet of sample strip through scattered slash, 91 sample piles, and a number of logs and lopped and unlopped tops are under observation.

The general progress of decay to the end of the calendar year 1930 may be summarized as follows:

First and Second Years: Extension of duff fungi, mostly of the filamentous type, to fallen needles and to foliage and bark of branches resting on ground. Some development of internal fungi in hanging or protected foliage, causing scattered eruptions through the needle epidermis. No development of decay in wood of twigs or branches except where the latter are partly buried in mineral soil. Decay in logs and larger tops of white fir and pine proceeds rapidly during the second year where the bark has not been skinned off in logging. In pine, the decay is confined to the sapwood.

Third to Fifth Years: Foliage in contact with ground is decayed to various degrees depending upon amount of shading or other protection. Pine foliage in interior of piles or within very thick layers of slash shows only light fungus action. Decay begins in twigs and branches buried in duff. Portions of branches buried in or in contact with mineral soil are badly rotted in some cases but the decay does not extend appreciably above ground. Rot development slows up in the logs and tops except where resting on the ground, and in pieces under 10 inches in diameter may cease almost entirely. The change is apparently brought about by bark loosening and checking of the wood, resulting in the latter becoming too dry to support fungus growth during the summer.

Fifth to Seventh Years: About 50% of foliage disintegrated, the rest in various stages of decay depending upon exposure, contact with ground or degree of protection. Pine foliage on the interior of pure pine piles still well preserved. Some decay, carbonaceous, stringy or punky in type, in twigs and branches buried in duff or in contact with the ground. In well protected spots a small amount of decay is also found in branches off the ground. Logs and tops show a great variation in condition, depending upon species, shade and degree of bark sloughing. In some, decay has progressed so far that they will no longer sustain a person's weight without caving in, while others appear comparatively sound.

On the Stanislaus area, it is estimated that not over 5% of the slash, under 4 inches in diameter is appreciably decayed at the end of the seventh year.

Checking of sugar pine limbs during seven years since cutting. Note also the insect galleries.

On the Lassen area very little decay, even in early stages, has appeared to date and the indications are that the rate of development of decay is going to be slower than on the Stanislaus area. It has been noted particularly that logs and tops have so far decayed less rapidly on the Lassen area.

Checking of white fir limbs during the seven years since cutting.

Very little fruiting of decay fungi has so far occurred on the experimental area so that the species of fungi mainly concerned in the rotting of the slash can only be guessed at through the type of rot produced. The Red Belt fungus (Fomes pinicola) is one of the principal fungi rotting white fir and pine logs and chunks but does not ordinarily work in material under 10 inches in diameter. Sporophores of the White Pouch fungus (Polyporus volvatus) appear abundantly on tops and down logs

during the second year but cause only a little decay of the wood. Two agarics, (Pholiota aurivella and Pleurotus sp.) have been found fruiting abundantly on down white fir logs and, undoubtedly, play a part in the decay of the sapwood of logs and tops of this species. In the smaller slash several fungi (Polystictus abietinus, Lenzites saeparia and Poria spp.) seem to be the most important, judging identities by the decay produced. The first-named fungus is common in larger material as well as limbs, and on the Stanislaus area promises to be the most important one at work in the slash.

On the whole, fungus decay has so far been less of a factor in the deterioration slash than had been expected when the experiments were initiated. In part, this can be accounted for by weather conditions. It is safe to say that fungus action is more dependent upon weather than any other factor concerned in slash deterioration and one favorable season may do more to further the progress of decay than several unfavorable ones. For instance, one year old slash was in approximately the same condition at the end of 1925, a year at least close to normal, as the two-year slash which had lain through 1924, an excessively dry year. There has been no really heavy snow year up to the end of 1930 since observations on decay were started, 1922 having been the last year with a deep snow pack. Light snows cause not only less flattening down of the slash and less action by the dark filamentous types of fungi which work under a snow cover, but they also result in an early drying out of the soil before air temperatures average high enough to favor fungus development.

Of the years 1922 to 1930 inclusive, there have been only two in which precipitation has been even slightly above normal in the pine region and there have been several years decidedly below normal. We can, therefore, consider the rate of decay so far attained on the slash areas as a minimum, indicative of what can be expected under the most unfavorable conditions likely to occur. A series of years more favorable to fungus growth probably would have resulted in much greater break-down of the slash.

Even with favorable years, however, decay can be expected to progress slower in California than in almost any other part of the United States, owing to the almost total absence of summer rains. Wood-decay fungi can develop only within certain ranges of temperature and moisture. In our timber belts, winter temperatures retard most fungus activity while, in summer, all except the largest or best protected pieces of slash become too dry for fungi to grow. Also, as determined by Gottlieb [10]

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[10] Gottlieb, A.W., "Relation between Subcortical Temperatures and size of white pine (Pinus strobus) Slash". Ecology 9: 243-248 1928.

subcortical temperatures in exposed slash may become high enough to inhibit the growth of, or even kill, fungi present.

EFFECT OF INSECTS UPON SLASH

In 1924, when the slash was from one to two years old, Dr. H. E. Burke, of the Bureau of Entomology, made an examination of the Stanislaus area. He stated his conclusions as follows:

> "In general, it may be said that at present the insects have played a small part in the disintegration of the slash examined. Most of the piled stuff is small and not infested. In the larger stuff scattered over the ground they have played a larger role. Practically all the white fir was infested with Chrysobothris dolata, C. pseudotsugee and Melanophila drummondi. Some species were infested with Monochamus oregonesis. All of these loosen the bark, especially the Monochamus. The sugar pine was infested with Chrysobothris caurina and Melanophila gentilis, and the yellow pine with the same. The incense cedar is heavily infested with Chrysobothris nixa, which is an efficient bark loosener.
>
> "The only potentially dangerous insects found in the slash are Melanophila drummondi, which sometimes attacks and kills white fir and Douglas fir, and Melanophila gentilis, which sometimes attacks and kills yellow pine and sugar pine, especially sugar pines like those left on the plot for second cutting. Ips confusus and Dendroctonus monticolae did not occur in sufficient numbers in the slash to be considered of importance. About 90 per cent of the insects noted belong to species of Chrysobothris and are not considered dangerous to living trees."

In 1930, when the slash was from eight to nine years old, Senior Entomologist J. M. Miller of the Bureau of Entomology, made a study of insect activities on the area. As a result of his observations, he stated two conclusions regarding the entomological phases of the study:

1. Insects, mainly secondary borers, have been an important factor in loosening the bark and destroying the cambium of limbs in the piled slash. This activity has occurred within the two seasons following cutting. In subsequent years, insects have not been a factor in disintegration of the piled slash.

2. No outbreak of insects destructive to living trees, which can be directly attributed to the slash left on the logged area has taken place, either on or near the area.

In addition to the insects noted by Dr. Burke in 1924, Miller found evidence of work by Callidium antennatum in pine limbs and Callidium pseudotsuga in white fir limbs. Both of these insects are bark looseners. They also sink pupation tunnels about two inches into the sapwood. The workings of Scolytus ventralis were also found on the surface of white fir sapwood. At the time of the examination, none of these insects were found in the material. Apparently, they had abandoned it about two years after the timber was felled.

Considerable damage to living white fir, both within and without the slash area, was being done by Scolytus ventralis. This loss could not be attributed to the presence of slash. Four small sugar pines, which had been injured during logging, were killed by Dendroctonus monticolae in 1928-1929.

EFFECT OF GRAZING ON SLASH

It is estimated by the Forest Supervisor, that 118 head of cattle graze the experimental area annually for the three months' period June 16 to September 30. The forage is fully utilized, without abuse.

Close observation of the area indicates that trampling by cattle has noticeably speeded up the disintegration of the slash, particularly after the bark has left the limbs and their strength has been lessened by transverse season checking. This trampling process, by breaking up the slash, exposes more wood surface to weathering and fungi action and also facilitates the construction of fire suppression trenches within the area. These benefits are not offset by any detectable adverse effect of grazing upon reproduction on this area.

EVIDENCES OF DECOMPOSITION

The decomposition process which is taking place in the slash due to the agencies just discussed is gradual and continuous. From year to year, the changes recorded by the material are slight, although over a period of years they are very marked. In order to secure as accurate a picture as possible of the slash disintegration which had taken place during an average period of seven years after the timber was felled, all material measured (See Fig.# 1) on 46 small sample plots was inspected and assigned to one of the six following most evident stages of decomposition:

(a) Bark tight and in place.

(b) Bark loose and in place. Limbs generally slightly season checked.

(c) Bark loose and partly sloughed. Limbs generally slightly season checked.

(d) Bark entirely sloughed. Medium season checking in evidence on all limbs.

(e) Bark entirely sloughed. Heavy season checking.

(f) Limbs broken into small cubical sections. Some evidence of decay.

The percentage of volume of the measured slash of each tree species, which falls within each of the above decomposition stages, is shown graphically in Figure 2.

Figure 1

VOLUME OF MATERIAL (HAZARD) RESULTING FROM DIFFERENT METHODS OF DEALING WITH SLASH

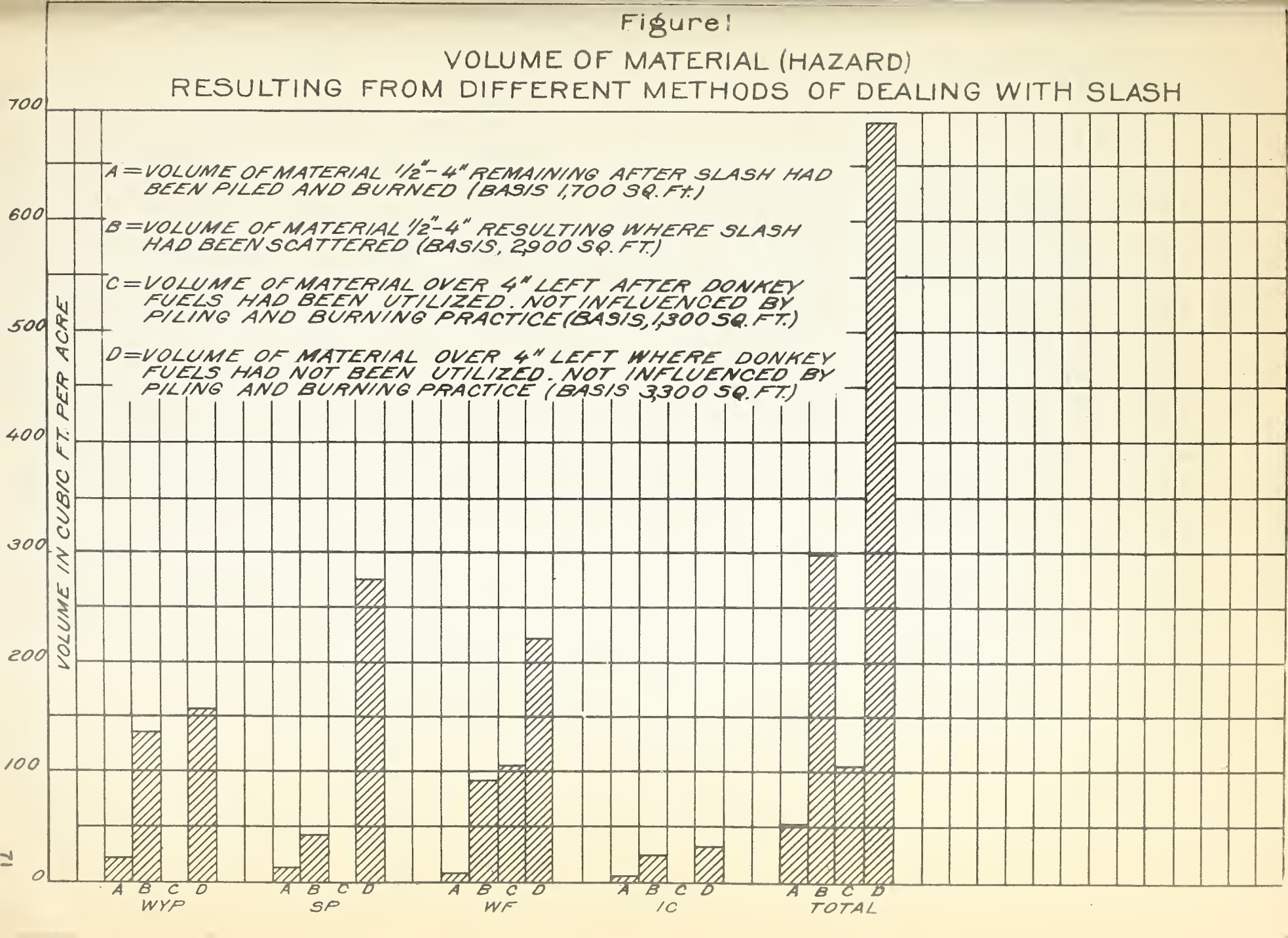
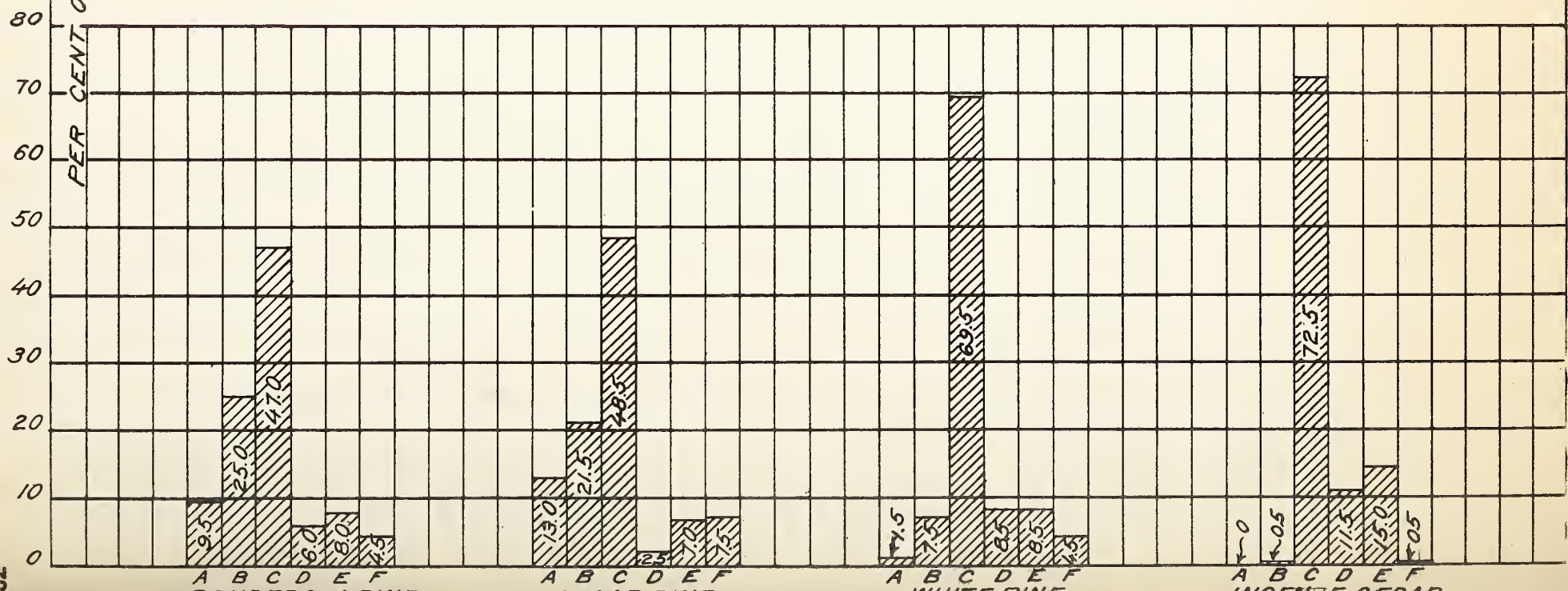


Figure 2

PROGRESSIVE STAGES OF SLASH DECOMPOSITION BY TREE SPECIES

A BARK TIGHT IN PLACE
B BARK LOOSE AND IN PLACE-LIMBS GENERALLY SLIGHTLY SEASON CHECKED
C BARK LOOSE AND PARTLY SLOUGHED LIMBS " " "
D. BARK ENTIRELY SLOUGHED - MEDIUM SEASON CHECKING IN EVIDENCE ON ALL LIMBS
E " " " HEAVY SEASON CHECKING
F LIMBS BROKEN INTO SMALL CUBICAL SECTIONS - SOME EVIDENCE OF DECAY



APPENDIX

EASTERN LASSEN HAZARD REDUCTION EXPERIMENT

COST COMPARISON OF BRUSH PILING AND BURNING AND FIREBREAK SYSTEM OF PROTECTION:

The facts set forth heretofore regarding the fire history of the experimental area during the five year period indicate conclusively that the firebreak system, as administered in this instance, has been remarkably successful when judged from the standpoint of acreage burned and values destroyed. Unfortunately, the Forest Service records do not furnish a fire history of comparable reliability for a similar area where brush piling and burning has been practiced. Such information must be secured before the end of the experimental period if the two systems are to be properly evaluated. The only information that we have of value indicates that, between 1926 and 1930 on ten National Forests where a large acreage of brush had been piled and burned, the average fire within the area so treated amounted to three acres, or a little over three times as much as the average fire on this area. While this is a good showing for the brush piling and burning system it must be admitted that it does not compare favorably with the results secured on either of the firebreak experimental areas which have been reported upon.

In undertaking a cost comparison on the firebreak systems as employed in the Eastern Lassen hazard reduction experiment with the system of piling and burning it seems apparent that our calculations may be simplified by eliminating snag disposal and lopping tops from the firebreak cost set-up. Snag disposal is generally recognized as an auxiliary of any effective protection system. It is not regarded as an inherent part of brush piling and burning costs, and therefore, may be canceled on both sides of our equation. Also, fire suppression is a separate activity which should be eliminated from our comparison.

It has been decided that the lopping of tops is unnecessary in this instance within the areas protected by firelines. However, this work is necessary in connection with the piling of brush and its cost cannot readily be isolated from other phases of brush disposal cost; therefore, this item may be canceled from the firebreak portion of our equation only.

Special roads and extra patrol and detection service are necessary in connection with the firebreak system of protection because of the unusual volume of hazard left on the ground. This hazard is largely disposed of by the brush piling and burning system.

We have then the following firebreak cost items for comparison with brush disposal costs: firebreaks, right-of-way clearing, special roads, clearing skid roads, patrol and detection, maintenance fire protection improvements, supplies and equipment. Eliminating Crater Mountain Unit, Compartment B from our calculations, a total expenditure for the five year period in connection with these seven activities amount to $79,334.31. This is equivalent to $3.65 per acre for the 21,726 acres cutover during the period, or 25 cents per M timber cut from affected acreage.

During the period with which we are concerned (1926 to 1930 inclusive) the Fruit Growers Supply Company have had but little experience with brush piling and burning work as handled on National Forest land. Cost records for these five years secured from five large operators in the eastern Sierra region who have handled a large amount of this work on National Forest land, indicate an average for brush piling of 45 cents per M, and an average cost for brush burning of 2.8 cents per M. A cost of 50 cents per M for this activity is considered a fairly liberal average for the period and the conditions under consideration. On this basis the total cost of disposing of the slash from the 344,172 M cut would have amounted to $172,086.00, or 217% of the total amount expended for the comparable portion of the firebreak system. The average cut from the area is 15.8 M. The total cost of brush disposal per acre, therefore, would have been $7.90 as compared to the per acre firebreak cost of $3.65.

In connection with the protection of the 21,726 acres cut over within this firebreak experiment, 146 miles of firebreak and 26 miles of right-of-way have been double fire trailed. This must be retrailed every three or four years in order to maintain the efficiency of the fire protection improvements. If it is assumed that the experiment will continue until 1940, or a total period of 15 years, then three additional retrailings will perhaps be necessary at a cost of about $12 per mile of double trail, or a total cost of about $6,000 (172 miles x $12 x 3).

Maintenance work must also be done about every three years, or three times within the remaining period, on the 83 miles of special roads. It is estimated that this will cost about $8 per mile or a total cost of about $2,000 (83 miles x $8 x 3).

While it is possible that maintenance work upon the area within the breaks may be necessary, it cannot be stated at this time what this work will consist of and therefore, no cost estimate can be made. Some brush cutting and burning may be necessary on portions of the breaks, and elsewhere down logs which were left within the fire trails when the clearing was done may have to be removed.

The additional future maintenance estimated amounts to $8,000, equivalent to 37 cents per acre, or 2.3 cents per M on the basis of the footage cut.

The special patrol and detection service on the acreage cut over for the remaining ten years in the estimated life of the experiment, if calculated on the basis of the past five years experience amounts to 55 cents per acre, or 3.5 cents per M.

These cost items may be summarized as follows:

Firebreak system, based upon 15-year period for acreage and stand cut up to termination of 1930.

	Per Acre	Per M
Cost 1926-1930, inclusive	$3.65	$0.23
Additional maintenance, 1931-40	0.37	0.023
Patrol and detection, 1931-40	0.55	0.035
	$4.57	$0.288
Brush piling system	$7.90	0.50
Difference	$3.33	$0.21

These costs indicate a very substantial actual saving for the past five year period and also a very substantial estimated saving for the fifteen year period through the use of the firebreak system instead of the brush piling system on the cutover area of 21,726 acres. In addition, it seems very probable that at the end of this period the firebreaks and special roads, at least, will have a considerable residual value, while if brush had been piled and burned the protective value of this work would have been nullified very largely by the accumulation of natural hazards. It does not appear probable that quite as elaborate a system of firebreaks will be kept up after the period of high hazard has passed. Perhaps about one-half of the present mileage of breaks will be considered sufficient by the forest managers of that day to afford a desirable degree of protection for the remainder of the cutting cycle.

Compound interest calculations have not been made in connection with this computation because, as has been said already, the authors subscribe to the view that protection charges should be regarded as a part of the cost of a sustained yield forestry undertaking and should be written off currently as a part of the operating cost of the timber harvested. These costs have been handled in this way by the Fruit Growers Supply Company during the past five years. Those who disagree with this system of cost keeping will find a complete basis in the cost table for calculating interest on any basis which suits their fancy.

EFFECT OF FIREBREAK SYSTEM ON FOREST GROWTH CONTRASTED WITH EFFECT OF PILING AND BURNING SYSTEM.

Ten percent of all large cutover national forest sale areas in the California region is cruised in gridiron fashion to determine the remaining stand and other results of cutting. Careful counts of young tree growth by standard size classes are made on one percent of all such areas cruised. The following tabulated information has been compiled from the results of this cruising work on representative areas within the sale to the Fruit Growers Supply Company.

TABLE 11.

PERCENTAGE OF AREA TEMPORARILY TAKEN OUT OF PRODUCTION AND PERCENTAGE OF YOUNG GROWTH DESTROYED BY BRUSH PILING AND BURNING AND FIREBREAK SYSTEMS.

	Brush Piling and Burning.		Firebreaks.	
By area	6%		8.54%	
By number destroyed				
Reproduction 0-6 ft. high	10.7%)		9.00%)	
" 6 ft. high to	)	9.1%	)	*9.1%
3.5" DBH	3.5%)		9.4%)	
Poles, 7-11.5 DBH	3.7%		6.4%	
Trees, 12 DBH and over	.27%		2.7%	

*An additional 6.74% of this reproduction was covered by slash. A considerable part of this will probably develop satisfactorily.

The percent of the area affected by brush piling and burning (6%) consists of the area beneath the piles and burned perimeter immediately adjacent. The percent affected by firebreaks (8.54%) consists of the area of breaks minus the portion of that area occupied by logging railroad grades. This area still supports a considerable amount of young growth and therefore is not directly comparable with the area temporarily taken out of production by the piling and burning operation. The percentages of young growth destroyed by number represents trees either killed by burning, or removed in the clearing operations incident either to preparing spaces for brush piling or thinning the area within the breaks. Apparently both methods destroy about the same percentage of young growth up to and including 3.5" D.B.H. The classes of young trees 6 feet high and larger evidently suffer more from the firebreak clearing operation than from piling and burning slash; also 6.74% of the seedlings and small saplings are covered, temporarily at least, by unpiled slash.

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